NS&T Program

National Status and Trends Program
for Marine Environmental Quality

ALASKA

NOAA vessel JOHN N. COBB one quarter mile from the Lamplugh Glacier, 1991, CDR J. Bortniak, NOAA Corps
(NOAA Photo Collection, NOAA Central Library)

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National Ocean Service
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Center for Coastal Monitoring and Assessment

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Disclaimer

Status and Trends of Contaminant Levels in Biota and Sediments of ALASKA

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INTRODUCTION

The Arctic and subartic regions are among the most pristine, fragile, and least studied environments on Earth, and the potential for environmental change due to anthropogenic causes is significant. The increased impact of oil and gas production and more recently of ecotourism may affect the environmental balance of the area in years to come. As part of its continuing mission to bring important results into the public arena, the NOAA National Status and Trends (NS&T) Program has prepared this summary of its findings in Alaska and compares them to those of the closest similar site in the contiguous U.S.

NATIONAL STATUS AND TRENDS PROGRAM

Our Nation's estuaries and coastal waters receive chemical wastes from industrial, municipal, and agricultural sources. In recent decades, as industrialization has grown and diversified, complex mixtures of synthetic organic compounds, trace elements, and nutrients have been discharged into US coastal waters.

In addition to coming from industrial sources, contaminants are released to the environment in the course of our daily lives. For generations, chemicals from such non-point sources as agricultural runoff, urban runoff, and non-agricultural insect and plant control programs have added significantly to the total burden of coastal contaminants. Airborne transport is another significant source of contaminants to coastal ecosystems. In recent years, coastal contamination has become more of a concern as population growth in these areas has continued to increase steadily. In response, an evolving national effort is underway to determine the extent and impact of contaminants on coastal and estuarine areas and to develop management strategies.

The Center for Coastal Monitoring and Assessment (CCMA), in the National Centers for Coastal Ocean Science (NCCOS) of NOAA's National Ocean Service, conducts a variety of environmental monitoring and assessment studies that are pertinent to NOAA's Environmental Stewardship mission as outlined in its Strategic Plan: "A Vision for 2005". These studies focus on three long-term goals:

- Assess the status and trends of environmental quality in relation to levels and effects of contaminants and other sources of environmental degradation in US marine, estuarine, and Great Lakes environments;

- Develop diagnostic and predictive capabilities to determine effects of contaminants and other sources of environmental degradation on coastal and marine resources and human uses of these resources;

- Develop and disseminate scientifically sound data, information, and services to support effective coastal management and decision making.

CCMA manages NOAA's NS&T Program that was initiated in 1984 to determine the status of, and to detect changes in, the environmental quality of the nation's coastal waters. This program monitors contaminant levels through the **Mussel Watch Project,** which determines concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, several pesticides, butyltins, and certain toxic elements in sediment and mollusk samples from U.S. coastal waters (Table 1). Data are used to determine the extent and temporal trends of chemical contamination on a nationwide basis and to identify which coastal areas are at greater risk in terms of threats to environmental quality. The Mussel Watch network consists of more than 280 sites. The **Quality Assurance Project** is designed to document sampling protocols, analytical procedures, and laboratory performances of the Mussel Watch Project and is an integral part of the NS&T Program.

SURVEY METHODS

Mussel Watch Project sites are sampled at regular intervals (biennially in winter for mollusks, less frequently for sediments). The sites are designed to describe national and regional distributions of contamination. Mussel Watch sites are selected to represent large coastal areas and to avoid small-scale patches of contamination, or "hot spots." Sites selected for monitoring are generally 10 to 100 km apart. Where possible, sites were selected to coincide with historical monitoring sites such as the Environmental Protection Agency's Mussel Watch sites sampled during the 1970s, and to complement sites sampled through state programs such as the California Mussel Watch Program (Lauenstein, 1996).

Mollusks (mussels or oysters) and sediments are collected at each Mussel Watch Project site. Several species of mollusks are collected: blue mussels (*Mytilus edulis*) from the US North Atlantic, blue mussels (*Mytilus* species) and California mussels (*M. californianus*) from the Pacific coast, eastern oysters (*Crassostrea virginica*) from the South Atlantic and the Gulf of Mexico, smooth-edge jewelbox (*Chama sinuosa*) from the Florida Keys, Caribbean oyster (*C. rhizophorae*) from Puerto Rico, Hawaiian oysters (*Ostrea sandvicensis*) from Hawaii, and zebra mussels (*Dreissena polymorpha* and *D. bugensis*) from the Great Lakes. Blue mussels are collected in Alaska. Coastal and estuarine mollusks are collected by hand or dredged from intertidal to shallow subtidal zones, brushed clean, packed in dry ice, and shipped to the analytical laboratory. Sediments are collected using a grab sampler and the top two centimeters are removed for analysis. The mollusk and sediment samples are usually shipped to the laboratory within a day of collection.

In the laboratory, molluscan samples are composited to include about 20 or 30 individuals for oysters and mussels, respectively. The molluscan composite samples and sediment samples are analyzed for organic and metal contaminants. The sampling and analytical protocols are described in detail in Lauenstein and Cantillo (1993, 1998). Data are also available from the NS&T **Benthic Surveillance Project** that analyzed contaminant levels and effects in sediment and fish from over 100 sites in 1984 through 1992. This Project's sediment data are combined with those of the Mussel Watch Project data in this report.

The NS&T Mussel Watch and Benthic Surveillance sites in Alaska and nearby coastal areas are shown in Figures 1 - 3. The site names, acronyms, latitudes and longitudes, years of data available, and human populations within 20 km of the sites are listed in Table 2 and shown in Figure 4.

The average concentrations of major and trace elements and organic compounds in mussels and fish liver are shown graphically in the Appendices I - III. Appendix IV provides graphical representations of trace element and organic concentrations in oysters through time at two sites.

TABLE 1

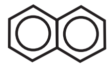
Organic contaminants and major and trace elements determined as part of the NS&T Program.

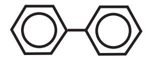
(Number below chemical structure is the Chemical Abstracts Service registry number.)

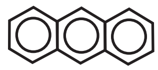
Polycyclic aromatic hydrocarbons

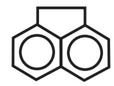
Low molecular weight PAHs
(2- and 3-ring structures)

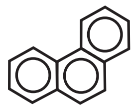
1-Methylnaphthalene
1-Methylphenanthrene
2-Methylnaphthalene
2,6-Dimethylnaphthalene
1,6,7-Trimethylnaphthalene
Acenaphthene
Acenaphthylene
Anthracene
Biphenyl
Fluorene
Naphthalene
Phenanthrene


Naphthalene
91-20-3

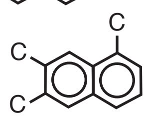

Biphenyl
92-52-4


Anthracene
120-12-7

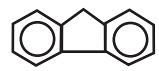

Acenaphthene
83-32-9

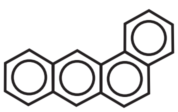

Phenanthrene
85-01-8

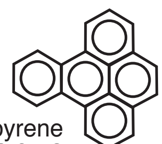

Acenaphthylene
208-96-8

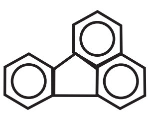


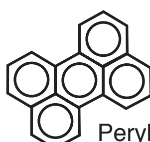
1,6,7-Trimethylnaphthalene
2245-38-7

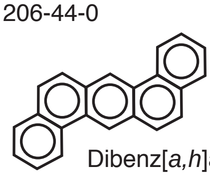

Fluorene
86-73-7

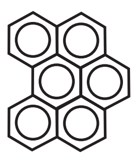

Benz[*a*]anthracene
56-55-3


Benzo[*e*]pyrene
192-97-2


Fluoranthene
206-44-0


Perylene
198-55-0


Dibenz[*a,h*]anthracene
53-70-3

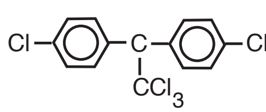

Benzo[*ghi*]perylene
191-24-2

High molecular weight PAHs
(4-, 5-, and 6-rings)

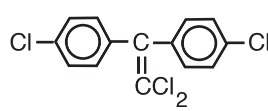
Benz[*a*]anthracene
Benzo[*a*]pyrene
Benzo[*b*]fluoranthene
Benzo[*e*]pyrene
Benzo[*ghi*]perylene
Benzo[*k*]fluoranthene
Chrysene
Dibenz[*a,h*]anthracene
Fluoranthene
Indeno[1,2,3-*cd*]pyrene
Perylene
Pyrene

Chlorinated pesticides

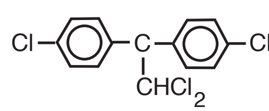
2,4'-DDD
4,4'-DDD
2,4'-DDE
4,4'-DDE
2,4'-DDT
4,4'-DDT



4,4'-DDT
50-29-3



4,4'-DDE
72-55-9



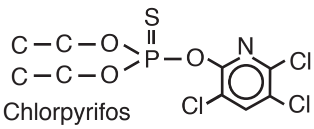
4,4'-DDD
72-54-8

TABLE 1 (cont.)

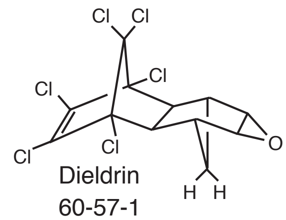
Organic contaminants, and major and trace elements determined as part of the NS&T Program.

(Number below chemical structure is the Chemical Abstracts Service registry number.)

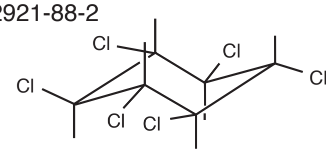
Aldrin
Chlorpyrifos
cis-Chlordane
Dieldrin
Endosulfan-II
delta-Hexachlorocyclohexane
gamma-Hexachlorocyclohexane
    (Lindane)
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
alpha-Hexachlorocyclohexane
beta-Hexachlorocyclohexane
Mirex
cis-Nonachlor
trans-Nonachlor
Oxychlordane



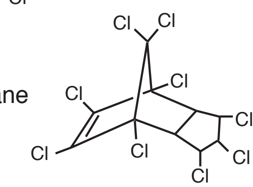
Chlorpyrifos
2921-88-2



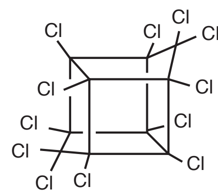
Dieldrin
60-57-1



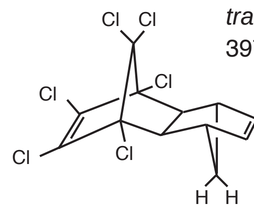
gamma-Hexachlorocyclohexane
58-89-9



trans-Nonachlor
39765-80-5



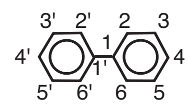
Mirex
2385-85-5



Aldrin
309-00-2

Polychlorinated biphenyl congeners (IUPAC numbering system)

PCB 8, PCB 18, PCB 28, PCB 44, PCB 52, PCB 66, PCB 101, PCB 105, PCB 118, PCB 128, PCB 138, PCB 153, PCB 170, PCB 180, PCB 187, PCB 195, PCB 206, PCB 209

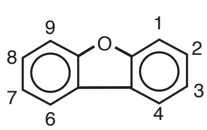


PCB parent structure

Planar PCBs (PCB 77, PCB 126, PCB 169)

Chlorinated dibenzofurans

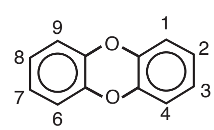
2,3,7,8-Tetrachlorodibenzofuran
1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-Hexachlorodibenzofuran
2,3,4,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-Hexachlorodibenzofuran
1,2,3,4,6,7,8-Heptachlorodibenzofuran
1,2,3,4,7,8,9-Heptachlorodibenzofuran
Octachlorodibenzofuran



Dibenzofuran parent structure

Chlorinated dibenzodioxins

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin
Octachlorodibenzo-*p*-dioxin



Dibenzo-*p*-dioxin parent structure

TABLE 1 (cont.)

Organic contaminants, and major and trace elements determined as part of the NS&T Program.

(Number below chemical structure is the Chemical Abstracts Service registry number.)

Major and trace elements

Al	-	aluminum	Cu	-	copper	Ag	-	silver
Si	-	silicon	Zn	-	zinc	Cd	-	cadmium
Cr	-	chromium	As	-	arsenic	Hg	-	mercury
Mn	-	manganese	Se	-	selenium	Tl	-	thallium
Fe	-	iron	Sn	-	tin	Pb	-	lead
Ni	-	nickel	Sb	-	antimony			

Organotins

Monobutyltin^{3+}, dibutyltin^{2+}, tributyltin^{+}, tetrabutyltin

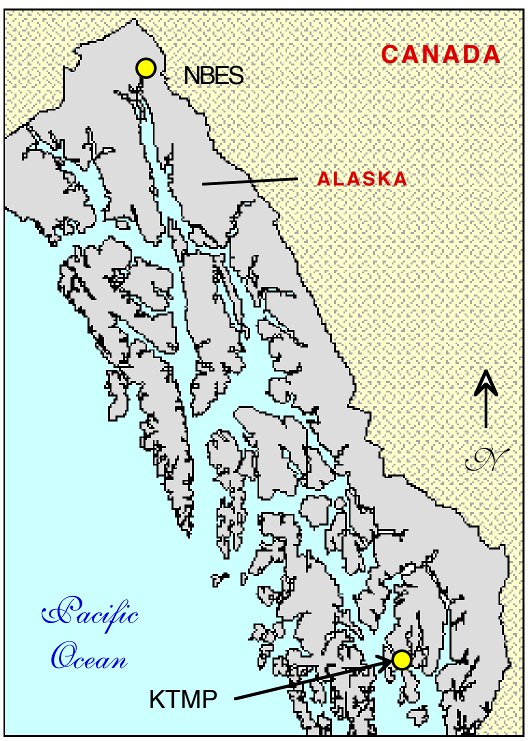


Figure 1. NS&T Mussel Watch Project sampling sites in the Panhandle of Alaska.

RESULTS AND DISCUSSION

Status

Mussels

Blue mussel specimens were collected in 1995 at ten stations along the southern coast of Alaska, and at Cape Flattery in the contiguous U.S. Most of these sites are located in remote areas with no visible signs of contamination. The Disk Island (PWDI) samples were collected along a 30-m long transect previously set up to monitor the effects of the Exxon Valdez oil spill. Although there were no obvious visible point sources of contamination in the area, a visible oily sheen on the adjacent cobble/pebble beach area was observed during Mussel Watch sampling. Oil "mousse" was found under the rocks and cobbles and in between the bivalves in the mussel beds (Jobling and Fay, 1996). The Mineral Creek Flats (PVMC) site can be accessed from Valdez, AK. The Port of Valdez lies at the southern end of the Trans-Alaska Oil Pipeline, and serves as a large oil terminal and storage depot. The port supports a sizable commercial fishing fleet throughout the year,

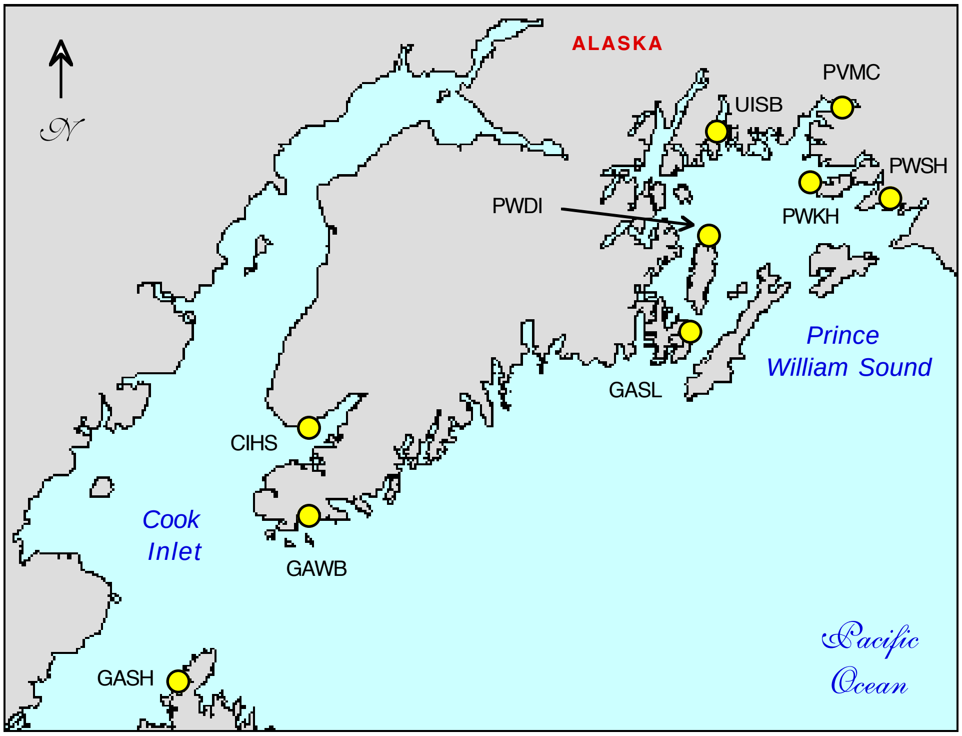


Figure 2. NS&T Mussel Watch Project sampling sites in Cook Inlet, Gulf of Alaska and Prince William Sound

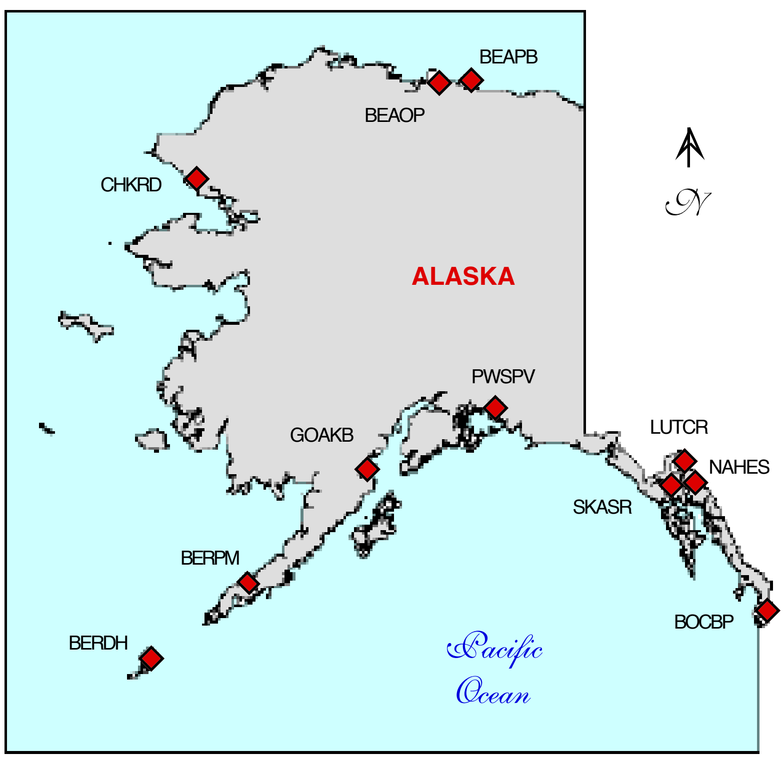


Figure 3. NS&T Benthic Surveillance sampling sites in Alaska.

TABLE 2

NS&T sampling sites in Alaska.

Site	Site code	Latitude (N)	Longitude (W)	Years of tissue data*	Population^Δ (20 km of site)
Mussel Watch Project (Blue mussel, *Mytilus edulis*)					
Shuyak Harbor	GASH	58° 30.06'	152° 37.31'	1	24
Windy Bay	GAWB	59° 13.12'	151° 31.02'	1	12
Homer Spit	CIHS	59° 36.87'	151° 26.65'	2	6,528
Sleepy Bay	GASL	60° 04.04'	147° 49.53'	1	97
Disk Island	PWDI	60° 29.58'	147° 39.35'	1	2
Siwash Bay	UISB	60° 57.65'	147° 38.76'	9	0
Mineral Creek Flats	PVMC	61° 07.97'	147° 27.66'	9	3,715
Knowles Head	PWKH	60° 41.28'	146° 35.01'	1	2
Sheep Bay	PWSH	60° 38.44'	145° 59.40'	1	2,238
East Side	NBES	59° 27.20'	135° 20.19'	2	723
Mountain Point	KTMP	55° 17.63'	131° 32.88'	2	12,663
Benthic Surveillance Project (Flathead sole, *Hippoglossoides elassodon*, unless noted)					
North Coast					
Prudhoe Bay◊	BEAPB	70° 21.0'	147° 57.0'	2	20
Oliktok Point◊	BEAOP	70° 30.0'	149° 58.0'	2	5
West Coast					
Red Dog Mine^H	CHKRD	67° 29.5'	164° 02.8'	2	0
Port Moller	BERPM	56° 03.0'	160° 45.0'	1	0
Dutch Harbor	BERDH	53° 54.0'	166° 30.0'	1	3,089
South Coast					
Kamishak Bay	GOAKB	59° 15.0'	153° 42.0'	1	0
Port Valdez	PWSPV	61° 07.0'	146° 08.0'	1	4,068
Panhandle					
Skagway River	SKASR	59° 26.6'	135° 19.7'	1	715
East Side	NAHES	59° 28.0'	135° 20.0'	1	717
Chilkoot River Mouth	LUTCR	59° 08.7'	135° 31.5'	2	1,812
Bacrian Point	BOCBP	55° 16.0'	130° 33.0'	1	0

Δ 1990 Census. The transient and/or summer population at some sites is higher than listed in the 1990 Census.
* Years of tissue data available through 1997.
◊ Four-horn sculpin, *Myoxocephalus quadricornis*.
H Starry flounder, *Platichthys stellatus*.

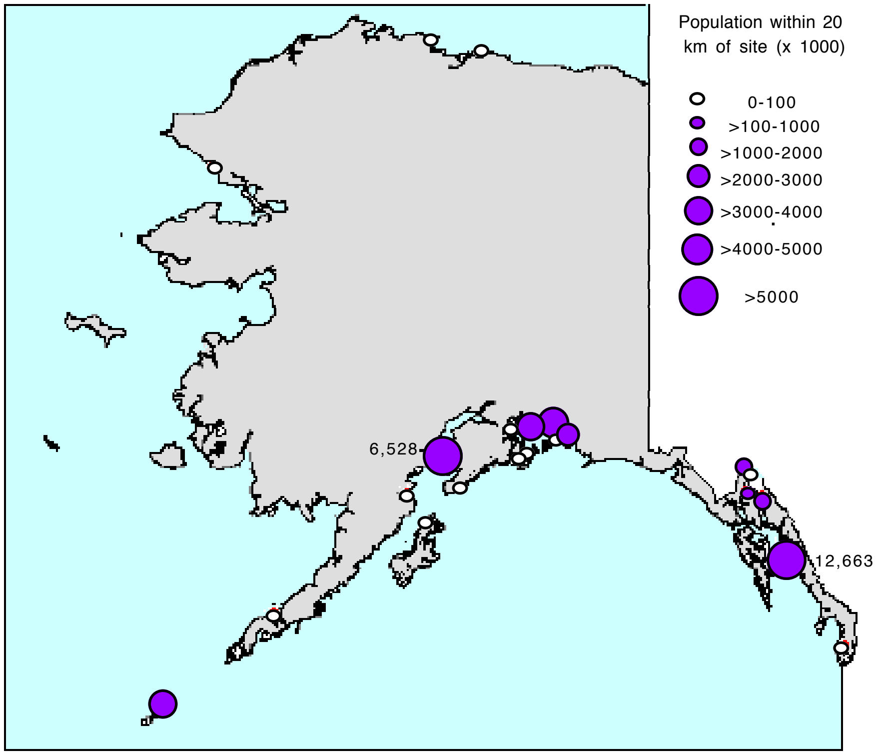


Figure 3. Population within 20 km of the NS&T sampling sites.

and is also a stop on the cruise ship route through Prince William Sound. The East Side (NBES) site in the Panhandle of Alaska is easily accessed from Skagway. There are a number of contaminant sources in the area. Lead ore and concentrate were loaded for many years at the nearby Skagway Harbor, and there were numerous spills into the Skagway River from heavy trucks failing to successfully traverse the Klondike Highway. There have been a number of minor fuel oil, gasoline, and diesel spills in the harbor during transfer of fuels from barges to dockside storage tanks. During the summer months, Skagway is visited by an average of three cruise ships per week. The Mountain Point site (KTMP) is easily accessed from Ketchikan, AK. There are a few potential sources of contamination including a small boat ramp and breakwater which are regularly used by local boaters and fishermen, and the channel between Mountain Point and Annette Island to the south is a major waterway regularly used by all the cruise liners, ferries, and commercial fishermen.

The closest comparable Mussel Watch site along the contiguous U.S. is Cape Flattery (JFCF), a remote site located at the mouth of the Strait of Juan de Fuca, WA. The nominal site center is 48° 23' N, 124° 43' W. This is a high energy wave site with no fine grained sediments so the sediment sampling site was established in Neah Bay (JFNB), WA, located to the east of Cape Flattery within the Makah Indian Reservation. The population within 20 km of the site is 1,214 people.

Oysters and mussels are not equal in their ability to concentrate trace elements (O'Connor, 1993). The trace elements Ag, Cu, and Zn are concentrated in the oyster *C. virginica* relative to the mussel *M. edulis.* Conversely, Pb is more than three times higher in the mussel than in the oyster. Therefore, only the NS&T mussel data were used to compare to the Ag, Cu, Pb, and Zn Alaska mussel data. The differences in bioaccumulation between oysters and mussels for Ni, As, Se, Cd, Hg, and the organic analytes are not sufficiently great as to prevent the combination of the data from the two bivalves.

Alaska, 1991, Cdr. J. Bortniak, NOAA Corps (NOAA Photo Collection, NOAA Central Library)

The concentrations of the NS&T analytes at the Alaska sites were compared to NS&T 85th percentiles values (Table 3). The 85th percentile is the value below which 85% of the values are found. Percentiles are robust with regard to both outliers and concentrations below the detection limit. Few of the concentrations found in the sample collected in 1995 exceeded the NS&T 85th percentile values. The ones that exceeded the NS&T 85th percentile were Ni at Sheep Bay, Siwash Bay, and Mineral Creek Flats; and Se at six of the eleven sites (Figure I.1). The high values of trace elements may reflect the mineralogy of the area. The organic analytes and aggregates were below the 85th percentile.

The trends at two of the sites, Siwash Bay and Mineral Creek Flats, will be described in the Trends section.

Fish

One of three species of bottom-dwelling fish, *Myoxocephalus quadricornis* (four-horn sculpin), *Hippoglossoides elassodon* (flathead sole), and *Platichthys stellatus* (starry flounder) was collected at each of the eleven Benthic Surveillance sites in Alaska. It was not possible to collect the same fish species at all sites.

Brief descriptions of the Benthic Surveillance sites are found in Meador *et al.* (1994). The Endicott Field site (BEAPB) is located west of an earthen causeway serving petroleum production facilities at Endeavor Island in the Beaufort Sea north of the Prudhoe Bay oil field. The Oliktok Point site (BEAOP) is in shallow water west of Oliktok Point which is the eastern edge of the Colville River delta and near one of the North Slope sealift barge staging areas in the Beaufort Sea. The Chukchi Sea site (CHKRD) is offshore near Kotzebue, where Pb and Zn ore transshipment for the Red Dog Mine, the world's largest producer of Zn, takes place (University of Idaho, 1999). The Port Moller site (BERPM) is in western Bristol Bay just off the entrance to the community of Port Moller which has been recommended for development as a support base for southern Bering Sea petroleum exploration, development, and production. The Dutch Harbor site (BERDH) is near a major support base for an international bottom-fish fleet which includes major container loading piers and small shipyards built on the site of a large World War II naval facility. The Kamishak Bay site (GOAKB) is located south of the active Augustine Island volcano and is an important commercial fishing and integration site for Cook Inlet, a major marine petroleum production area. The Port Valdez site (PWSPV) is along the northern side of a narrow fjord at the head of Prince William Sound which serves as the marine terminal for the Trans-Alaska Pipeline System and its associated ballast water treatment facility. The new town of Valdez on the north side has developed a small boat facility and receives commercial freight traffic. This site is different from the Mussel Watch sites in the area (UISB and PVMC) because the Mussel Watch sites are further removed from commercial activities. The Lutak Inlet site (LUTCR) is a reference site for the National Benthic Surveillance Project Alaskan sites. It is located between the ports of Haines and Skagway in an arm off Lynn Canal. The Nahku Bay site (NAHES) is in an embayment about 2 km north of the port of Skagway near the head of Taiya Inlet. The Skagway site (SKASR) is in the harbor area at the port of Skagway adjacent to the ore loading docks which recently have seen a shift from mineral and commercial commerce to large cruise ship operations. The Boca de Quadra site (BOCBP) is in a deep fjord and is near Quartz Hill, containing 11% of the world's molybdenum deposits (Daniel, 1992).

TABLE 3

NS&T Mussel Watch Data medians and 85th percentile values (1986 - 1997)

(Medians and percentiles were determined using the average at each site across all sampled years. Element data in µg/g dry wt. unless noted, and organic data in ng/g.).

Mussel data only (Calculated using *Mytilus edulis* and *M. californianus* data only.)

	Cu	Zn	Ag	Pb
n	124	123	121	124
Median	9.2	130	0.12	1.8
85th percentile	12	170	0.56	4.6

Mussel and oyster data

	Ni	As	Se	Cd	Hg
n	281	281	281	281	280
Median	1.9	9.2	2.8	2.8	0.10
85th percentile	2.1	16	3.9	5.9	0.21

	∑DDTs	∑PCBs	∑PAHs	∑Cdane	∑Dieldrin
n	280	280	268	280	280
Median	33	100	300	10	5.1
85th percentile	140	450	1200	32	15

	Mirex	Hexachloro-benzene	Lindane	Endrin	∑BTs
n	280	280	280	45	250
Median	0.24	0.23	1.2	0.38	54
85th percentile	1.2	1.1	2.8	2.3	200

Sediment data (Calculated using Mussel Watch Projectsediment data only.)

	Al (%)	Si (%)	Cr	Mn	Fe (%)
n	223	178	222	199	223
Median	2.4	3.0	54	370	2.1
85th percentile	4.8	36	120	740	3.7

	Ni	Cu	Zn	As	Se
n	223	223	223	223	207
Median	17	14	67	6.9	0.38
85th percentile	36	47	130	12	0.74

	Ag	Cd	Sn	Sb	Hg
n	223	223	223	178	223
Median	0.11	0.19	1.3	0.47	0.057
85th percentile	0.59	0.56	3.1	1.8	0.22

TABLE 3 (cont.)

	Tl	Pb	TOC (%)	∑DDTs	∑PCBs
n	145	223	220	224	224
Median	0.073	18	1.0	2.9	15
85th percentile	0.56	40	2.4	18	80

	∑PAHs	∑Cdane	∑Dieldrin	Mirex
n	224	224	224	224
Median	380	0.51	0.30	0.002
85th percentile	2300	3.1	1.9	0.36

	Hexachloro-benzene	Lindane
n	223	224
Median	0.14	0.04
85th percentile	0.92	0.47

∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.
∑PAHs: The sum of concentrations of the 18 PAH compounds.
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor, and heptachlor epoxide.
∑Dieldrin: The sum of dieldrin and aldrin.
∑BTs: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).
n: Number of data points (roughly equivalent to the number of sampling sites).

Dutch Harbor, Aleutian Islands, Alaska, 1953, RADM H. D. Nygren, NOAA Corps (ret.)
(NOAA Photo Collection, NOAA Central Library)

The closest Benthic Surveillance site in the contiguous U.S. is Elliott Bay (PUGEB) in Puget Sound, WA. *Parophrys vetulus* (English sole) specimens were collected at this site in 1984, 1985, and 1986. Specimens of *Hippoglossoides elassodon* (flathead sole) were also collected at this site during 1984. This site is located within the Seattle metropolitan area and thus is not comparable in population density with the Alaska sites. The population within 20 km of the PUGEB site is 981,561 people.

The concentrations of the analytes in the liver of the fish specimens collected all years at the Alaska sites and at the reference site in Elliot Bay are displayed in Appendix III. Some of the observed variations may be the result of species differences and/or the effects of the human population levels near the sampling sites. The elevated levels of As and Se that naturally occur in parts of Alaska (University of Idaho, 1999; Alaska Conservation Alliance, 1998; and others) are not reflected in the NS&T fish liver concentrations of these elements. The samples collected at the comparison site in Elliot Bay have higher levels of Fe, Pb, ∑DDTs, chlordane pesticides, dieldrin and aldrin, lindane, and mirex than the sites in Alaska. The highest levels of Hg and hexachlorobenzene were found in specimens collected at the sites on the north coast. Hexachlorobenzene and other chlorinated pesticides are purely man made and their presence indicates anthropogenic impact regardless of low human population. The levels of PCB congeners were below the limit of detection. Fish metabolize PAHs so these compounds are present in low levels in fish liver tissues and are not usually detectable by the analytical methods used.

Sediment

In addition to the Mussel Watch sampling sites, sediments were collected at the Benthic Surveillance sites in Alaska. Major and trace element concentrations above the NS&T 85th percentile values were found for: Cr at Red Dog Mine, Siwash Bay, Mineral Creek Flats, and Port Valdez; Mn at most sites on the south coast and the panhandle; Ni at Siwash Bay and Mineral Creek Flats; Cu at Dutch Harbor, Mineral Creek Flats, and Port Valdez; Zn at Mineral Creek Flats, Port Valdez, Skagway River, East Side, and Chilkoot River Mouth; As at Siwash Bay and Mineral Creek Flats; Se at East Side; Cd at Dutch Harbor, East Side, and Chilkoot River Mouth; Sn at Port Moller and Bacrian Point; Sb at Siwash Bay and Mineral Creek Flats; Hg at Dutch Harbor and East Side; and Pb at Skagway River and East Side. The trace organic levels in sediments were very low except for the concentrations above the NS&T 85th percentile for lindane at Port Moller, Kamishak Bay, Port Valdez, and Skagway River. No apparent correlation was found between human population within 20 km of the site and levels of NS&T analytes in sediments. In general, trace metal values found at the Alaska sites are approximately equal to or lower than those found at the comparison site on the contiguous U.S.

Principal component analysis using the NS&T sediment data indicates that three major sources account for 73% of the variance of the total organic carbon (TOC), Al, Si, Cr, Mn, Fe, Ni, Cu, Zn, Se, As, Ag, Cd, Hg, and Pb data. The major factor accounting for 34% of the variance is the clay and ferro-manganese oxyhydroxide component, accounting for loadings of Al, Mn, Fe, Cr, Ni, Cu, and As. Naidu and Mowatt (1974) reported a ferromanganese hydrate or an argillaceous fraction in continental shelf sediments of the Beaufort Sea. The next largest factor accounting for 25% of the variance and with the highest loadings for Si and Cr is the heavy mineral component. The third factor accounting for 13% of the variance and the highest loadings are for Se and TOC.

With two exceptions, the combined NS&T major and trace element sediment data can be sorted into four groups based on mineralogy and potential human impact: North Coast, West and South Coasts, Prince William Sound, and the Panhandle data sets. The exceptions are the data for the Red Dog Mine (CHKRD) and Prince William Sound Port Valdez sites (PWSPV). Examples of the data groups are shown in Figure II.17. The Red Dog Mine area is known to have naturally large concentrations of trace metals and its geochemistry appears to be different than that of the rest of the Alaskan sites, with naturally high toxic metals concentrations (Alaska Department of Environmental Conservation, 1997). The data from Port Valdez site should be grouped with the Prince William Sound data. The differences observed in trace element concentrations may be due to anthropogenic activities in the area.

Some Tl chemical species are extremely toxic and the element is listed in the EPA list of toxic elements (Keith and Telliard, 1979). Thallium is present in pyrites and is recovered from roasting this ore in connection with sulfuric acid production. It is also a by-product of Pb and Zn ore smelting. The Zn and Tl sediment data at the Alaska NS&T sites and Neah Bay, the comparison site in Cape Flattery, show clear differentiation of three of the four geographical areas (Figure II.18). The NS&T Tl and Zn levels are within the range found by Turekian and Wedepohl for clays, and ultrabasic and basaltic rocks. No apparent Tl contamination was observed on the Alaskan coast.

In summary, the major and trace element levels found in sediment probably reflect local mineralogy and not anthropogenic effects.

Trends

Contamination trends at the NS&T sites around the US from 1986 through 1995 have been identified by statistically comparing annually measured concentrations in mollusk samples from each of 186 sites that were sampled for at least six years. Calculations for each chemical at each sampling site showed increasing, decreasing, or no trends over time. The most common observation was no trend, but when trends were found decreases greatly outnumbered increases. Contamination is decreasing for chemicals whose use has been banned, such as chlordane, DDT, and dieldrin, or severely curtailed, such as tributyltin and cadmium. For other chemicals there is no evidence, on a national scale, for either increasing or decreasing trends (O'Connor, 1996). Table 4 shows the numbers of sites with Increasing (I), Decreasing (D), or No Trends (NT) in concentrations of each chemical.

The numbers in Table 4 are the result of a statistical test that will identify random sequences as real trends about 5% of the time. Since 186 sites were examined for each chemical, this means that about 10 of the trends per chemical could be due to random variations. That is why we have not given much weight to the relatively few trends that appear for most of the trace elements and for ∑PAHs.

Statistical correlations were also developed for the median (50th percentile) value of chemical concentrations among all sites sampled in each year from 1986 to 1995. These plots of annual medians show, at this national level of aggregation, a decreasing trend for As in mussels at Siwash Bay, and an increasing trend for Hg at Mineral Creek Flats.

CONCLUSIONS

In general, environmental conditions in Alaska, as determined by using results of the NS&T Program mussel tissue samples, indicate no obvious trends in contaminant concentrations during the course of the monitoring effort. The levels of major and trace elements in sediment appear to reflect local mineralogy and not anthropogenic impacts.

ACKNOWLEDGMENTS

The authors wish to thank the numerous chemists at the NOAA National Marine Fisheries Service, Battelle Ocean Sciences, and Texas A&M University, and A. E. Theberge (NOAA Central Library) for graphics support.

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TABLE 4

National trends in chemical concentrations measured as part of the NS&T Mussel Watch Project and trends for two Alaska area sites (PVMC and UISB) for which data exist for the years 1986-1993.

Aggregated chemicals*	Trend I	Trend D	Trend NT	Element	Trend I	Trend D	Trend NT
∑Cdane	1	81	104	As	11	11 (1)	164
∑DDTs	1	38	147	Cd	3	28	155
∑Dield	1	32	153	Cu	7	14	165
∑PCBs	1	37	148	Hg	7 (1)	9	170
∑PAHs	3	3	180	Ni	6	8	172
∑BTs	0	18	168	Pb	14	9	163
				Se	8	9	169
				Zn	7	9	170

I - Increasing; D - Decreasing, NT - No trend.
* Individual organic compound concentrations have usually been aggregated into these groups:
∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.
∑PAHs: The sum of concentrations of the 18 PAH compounds.
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide.
∑Dieldrin: The sum of dieldrin and aldrin.
∑BTs: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).

Inlet in Glacier Bay, Alaska, 1991, CDR J. Bortniak, NOAA Corps (NOAA Photo Collection, NOAA Central Library)

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NS&T DATA AND INFORMATION PRODUCTS

Data and information resulting from CCMA activities are made available to users and the scientific community at large in different formats and media.

NOAA Technical Memoranda provide detailed accounts of methods, data summaries, and results of various NS&T Program projects and related activities, such as sediment toxicity surveys, analytical methods, and sediment quality assessments.

Digitized data and program information about the NS&T program are available via electronic mail. Presently, data from the Mussel Watch project (1984-1994) and the Benthic Surveillance project (1984-1992) can be retrieved by downloading from the NCCOS Information Service which can be accessed at (http://seaserver.nos.noaa.gov). New data sets are added to the service as they are digitized and checked for accuracy. The data sets can also be requested from the CCMA office.

Scientific publications containing the results of CCMA projects are published as research papers in journals, books, and proceedings of professional conferences. The publications are authored by CCMA staff, contractors, and collaborators in different agencies. A cumulative list of these publications is issued periodically.

For further information on the NS&T Program or to obtain a list of available publications, write:


Mussels (TAMU/GERG)

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APPENDICES

Appendix I

Mussel data

Appendix II

Sediment data

Appendix III

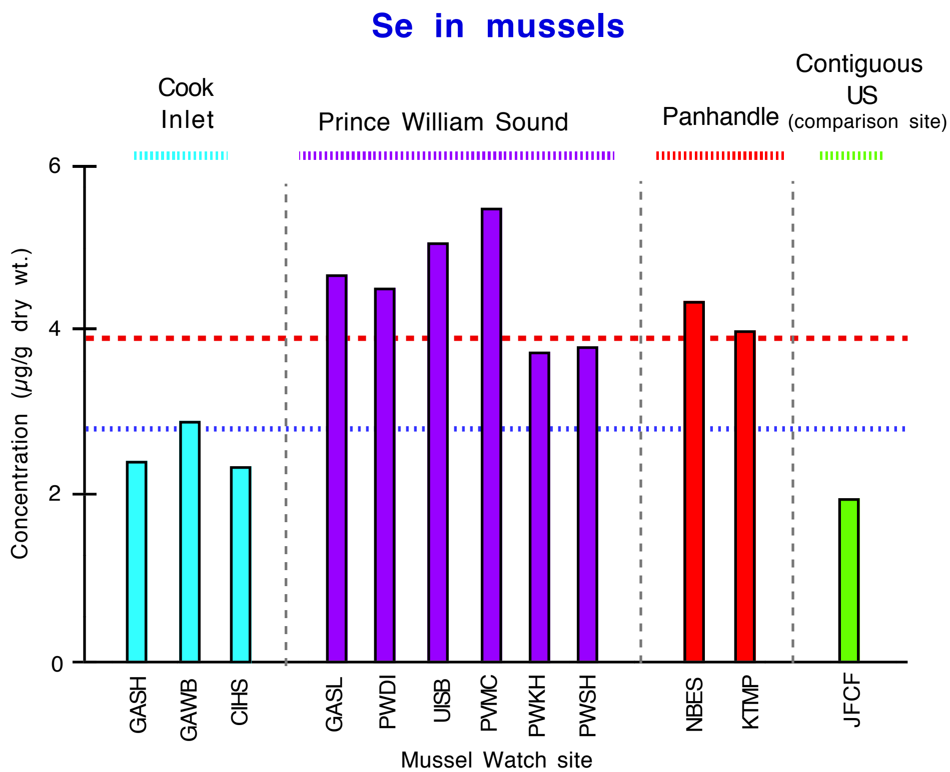
Fish data

Appendix IV

Trace element and organic trends in mussels at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US contiguous US reference site

Appendix I

NS&T mussel data for Alaska



Sites:				
Cook Inlet			**Panhandle**	
	GASH	Shuyak Harbor	NBES	East Side
	GAWB	Windy Bay	KTMP	Mountain Point
	CIHS	Homer Spit	**Contiguous US (comparison site)**	
Prince William Sound			JFCF	Cape Flattery
	GASL	Sleepy Bay		
	PWDI	Disk Island		
	UISB	Siwash Bay	(1995 data for Alaska sites and 1994 data for contiguous US site.)	
	PVMC	Mineral Creek Flats		
	PWKH	Knowles Head		
	PWSH	Sheep Bay		

Figure I.1. Selenium in mussels. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile (µg/g dry wt.).

Appendix II

NS&T sediment data for Alaska

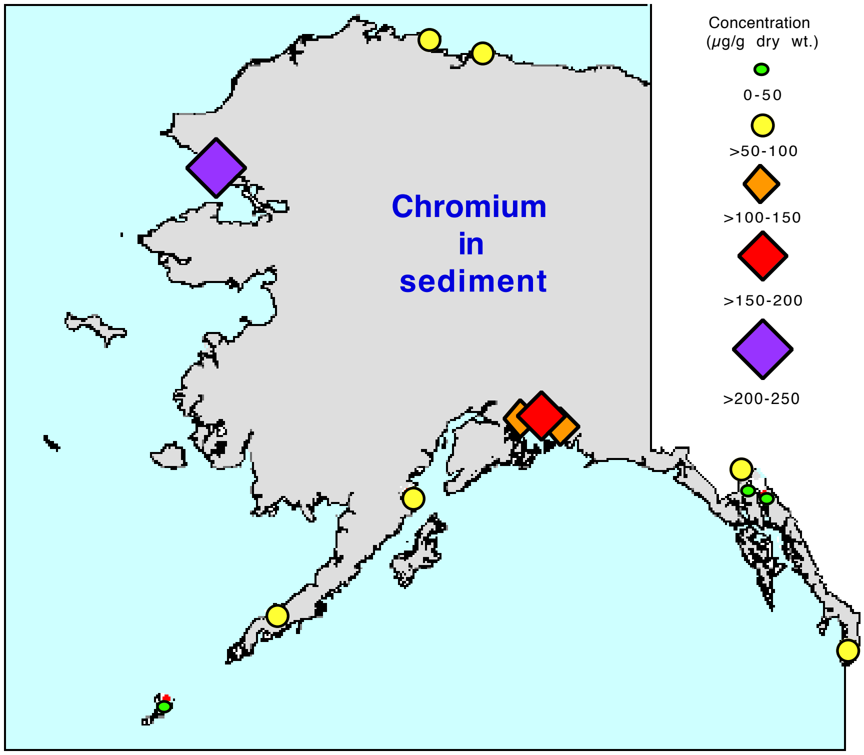


Figure II.1. Chromium in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Small island near Hoonah, 1991, CDR John Bortniak, NOAA Corps (NOAA Photo Library)

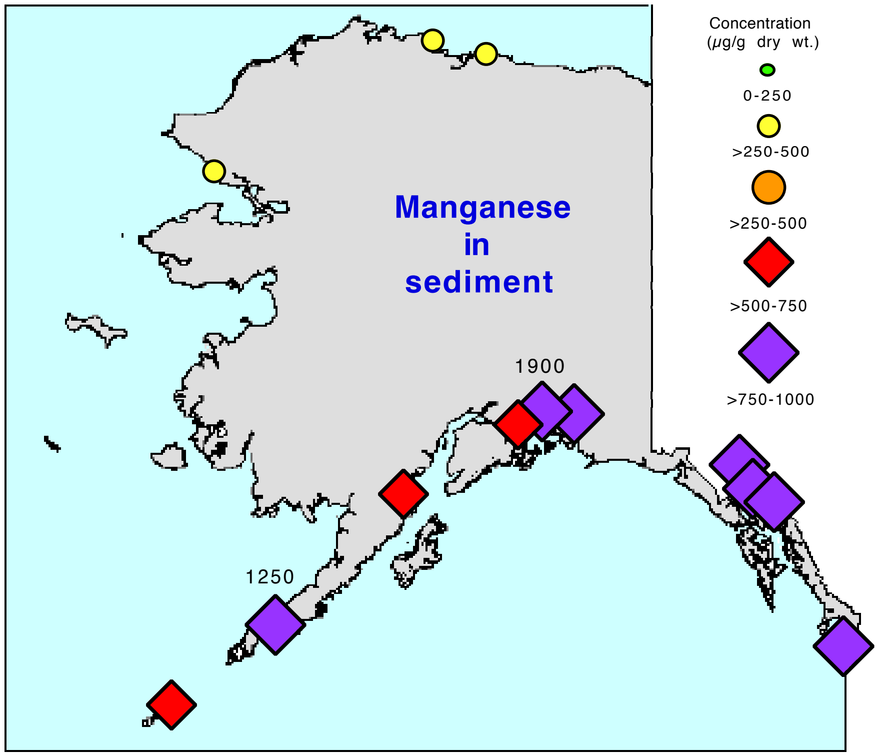


Figure II.2. Manganese in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

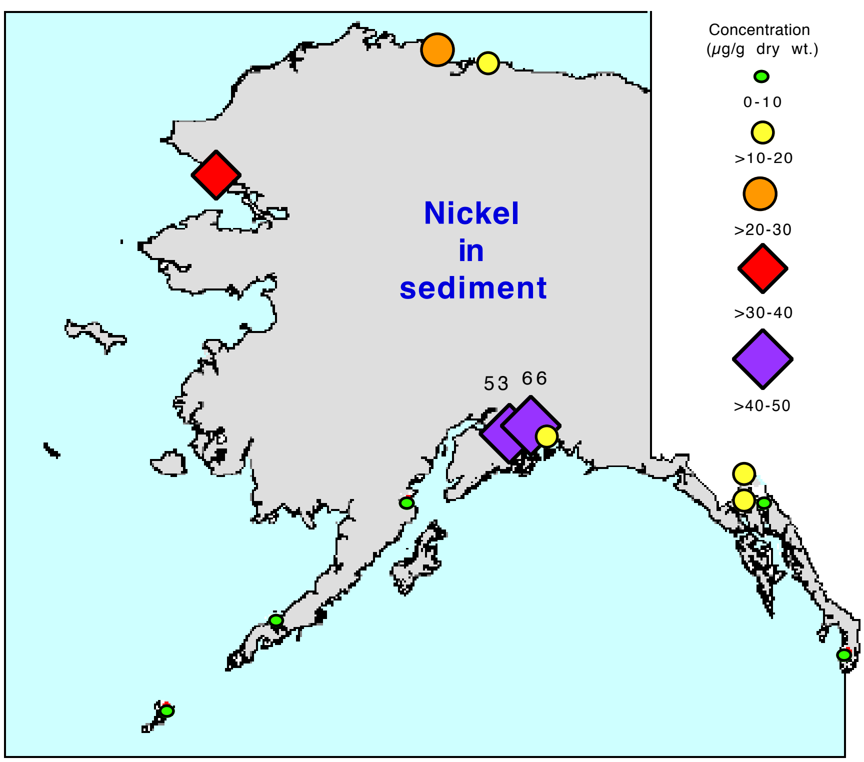


Figure II.3. Nickel in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

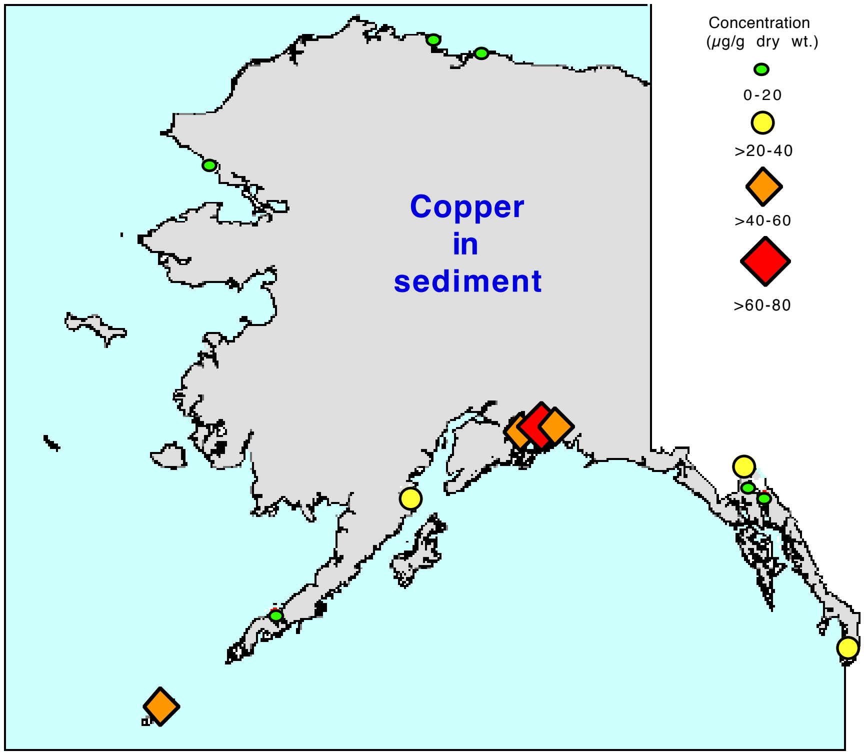


Figure II.4. Copper in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

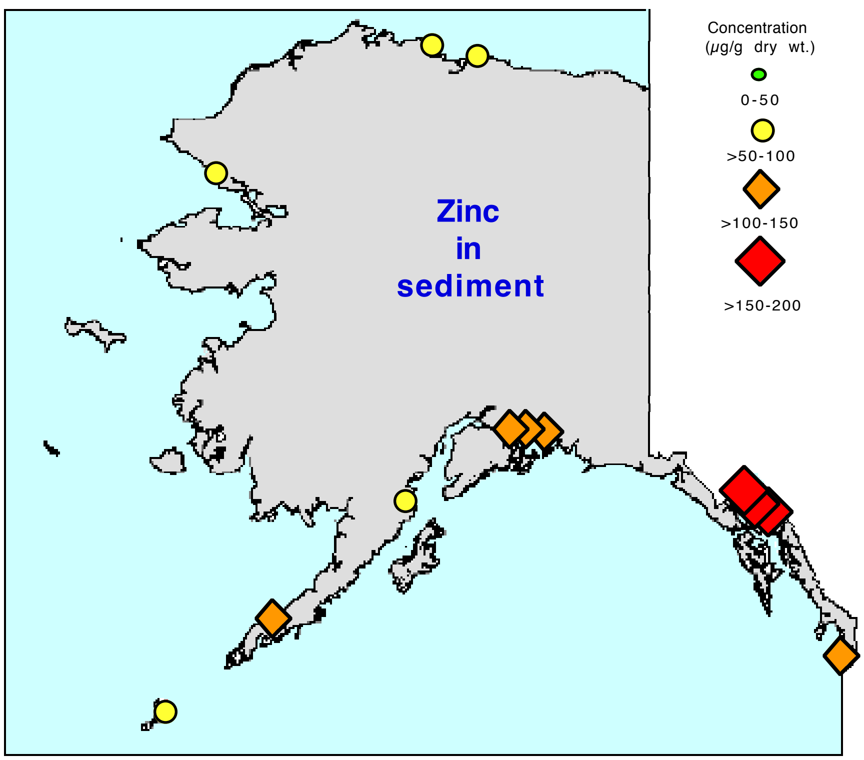


Figure II.5. Zinc in sediment. Average of data from 1986 to 1995. Concentrations were above the NS&T nationwide 85th percentile (µg/g dry wt.).

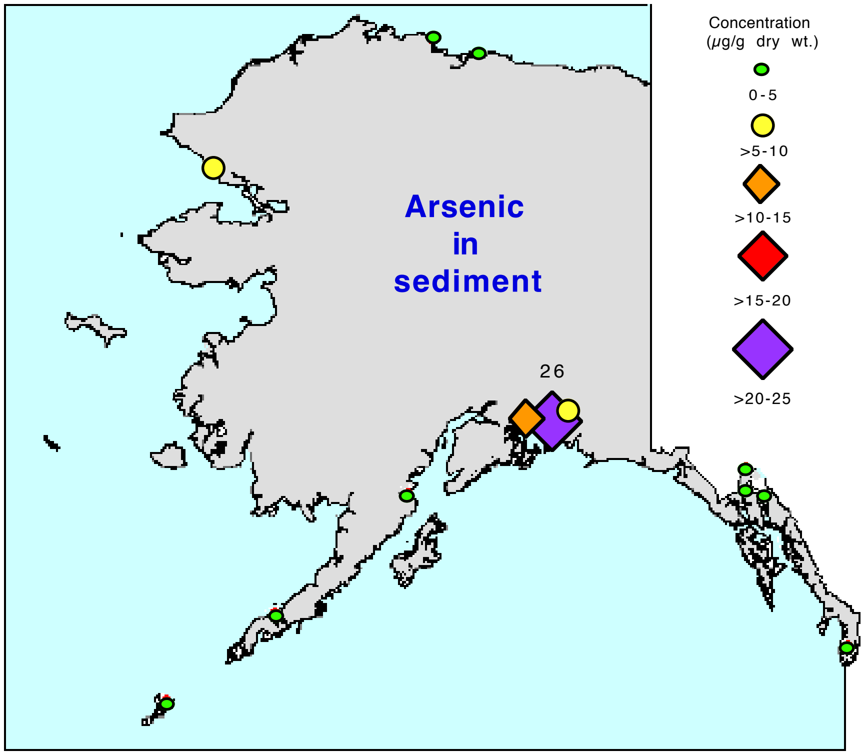


Figure II.6. Arsenic in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

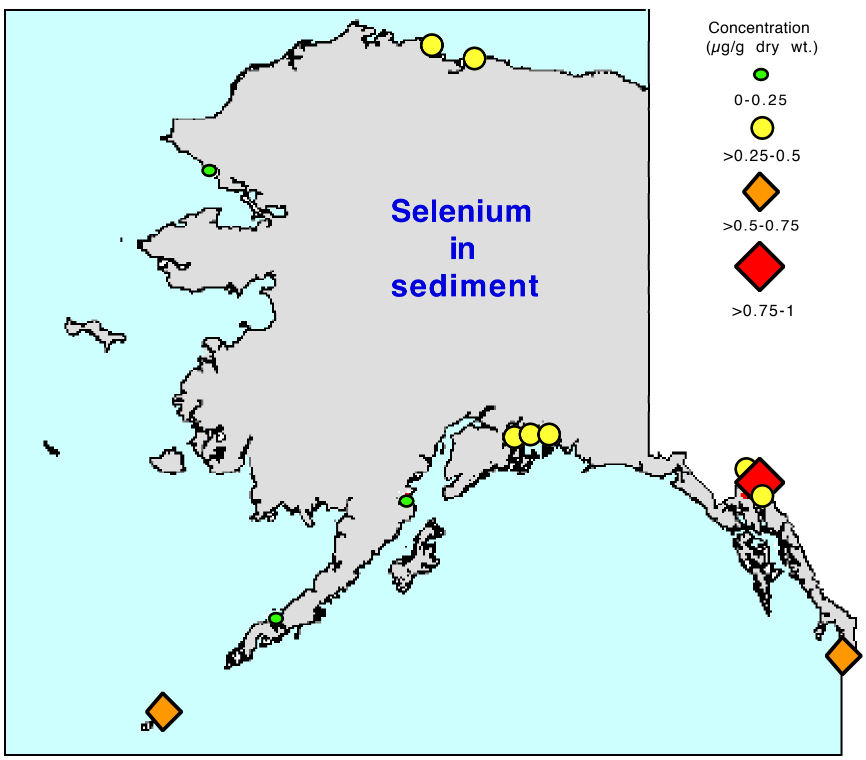


Figure II.7. Selenium in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

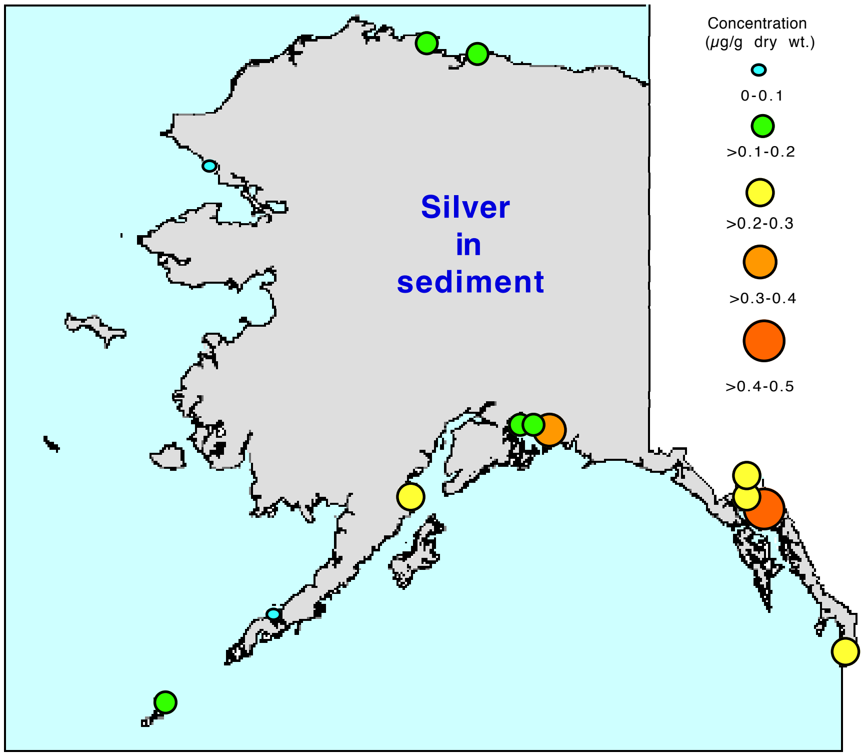


Figure II.8. Silver in sediment. Average of data from 1986 to 1995. All concentrations were below the NS&T 85th percentile (ng/g dry wt.).

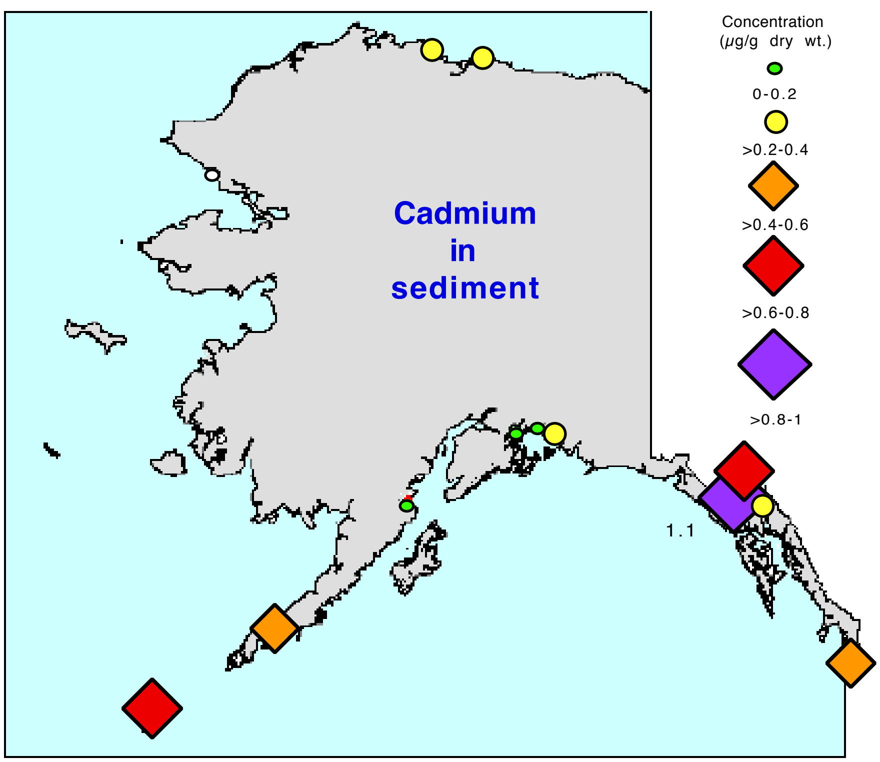


Figure II.9. Cadmium in sediment. Average of data from 1986 to 1995. A white circle denotes values below the limit of detection. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

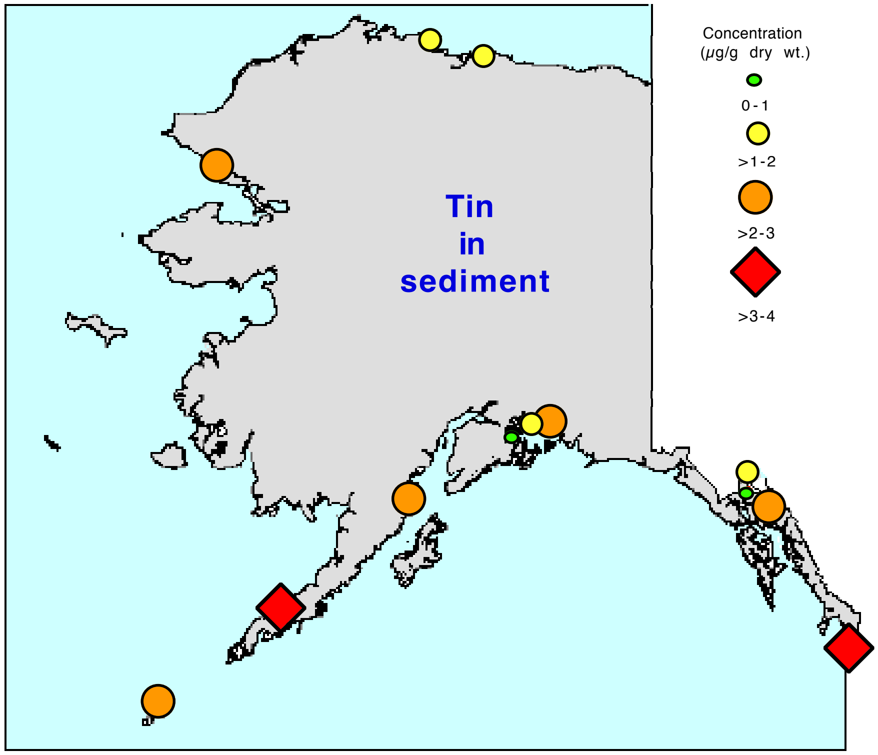


Figure II.10. Tin in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T 85th percentile (µg/g dry wt.).

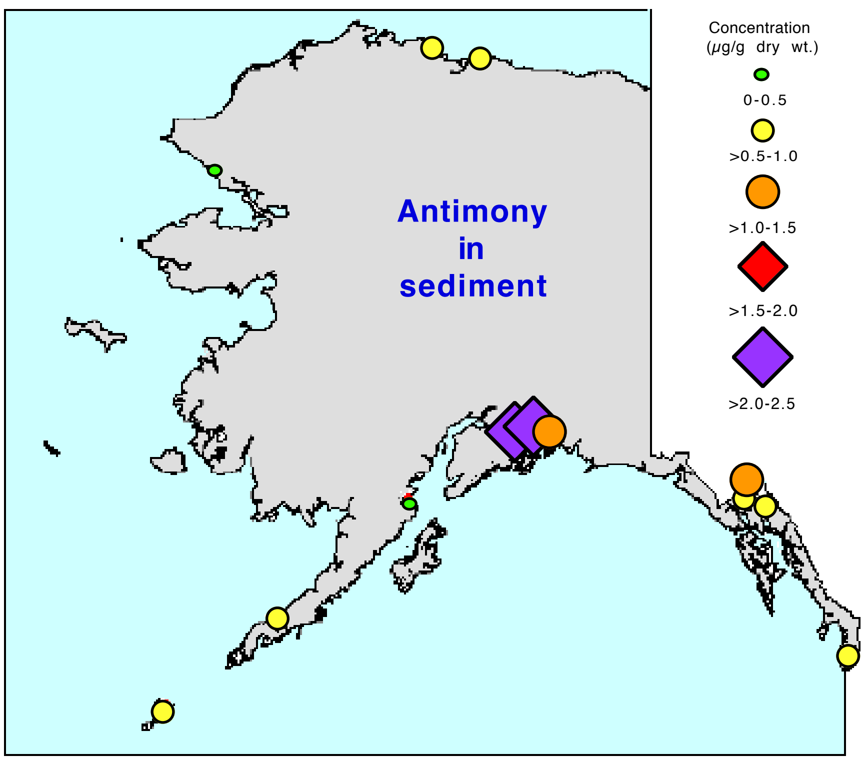


Figure II.11. Antimony in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T 85th percentile (µg/g dry wt.).

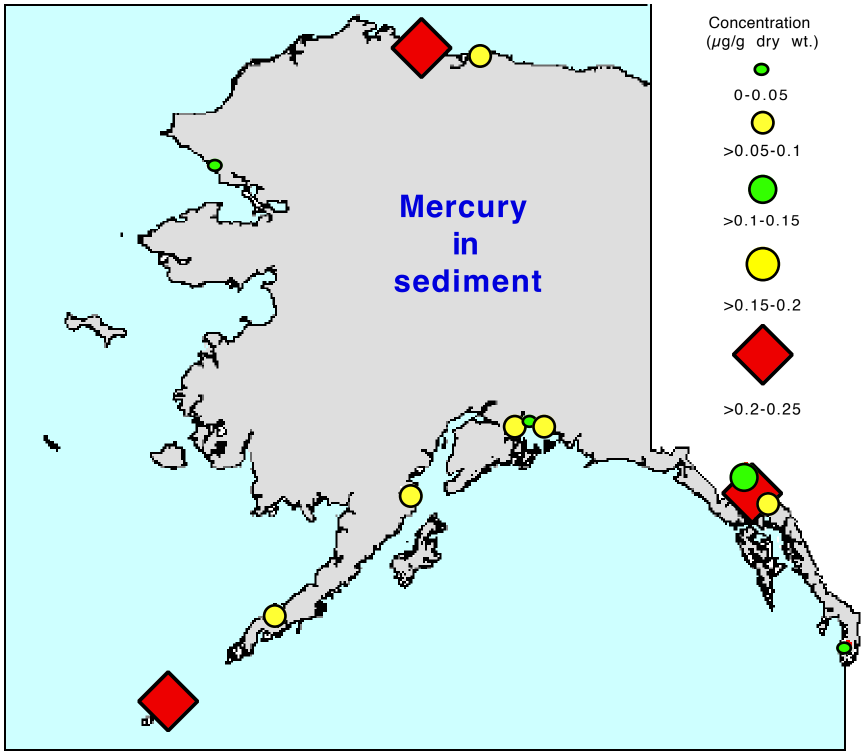


Figure II.12. Mercury in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T 85th percentile (µg/g dry wt.).

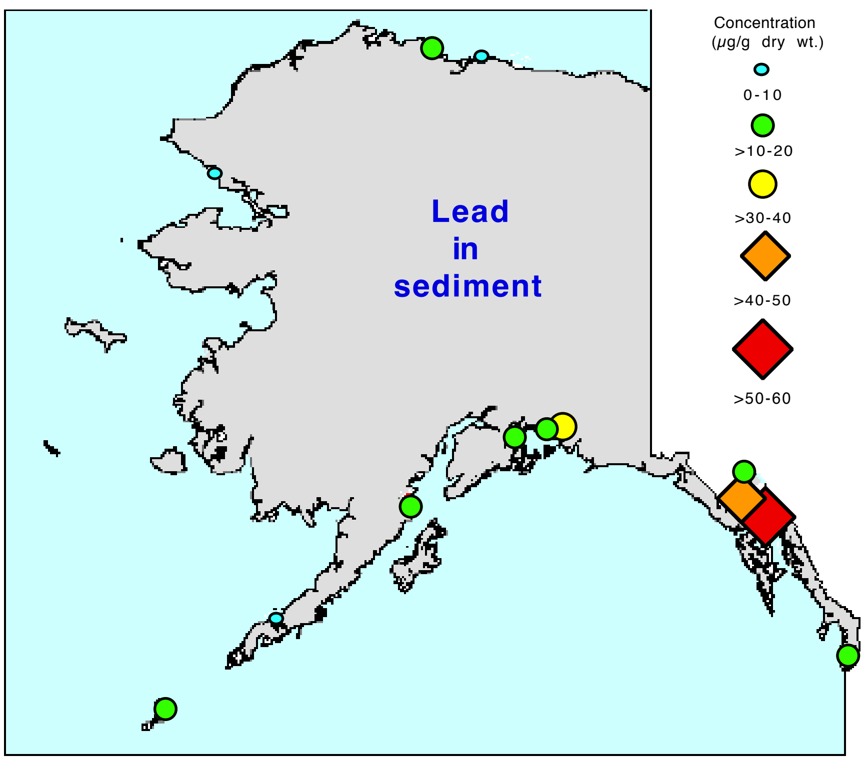


Figure II.13. Lead in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T 85th percentile (µg/g dry wt.).

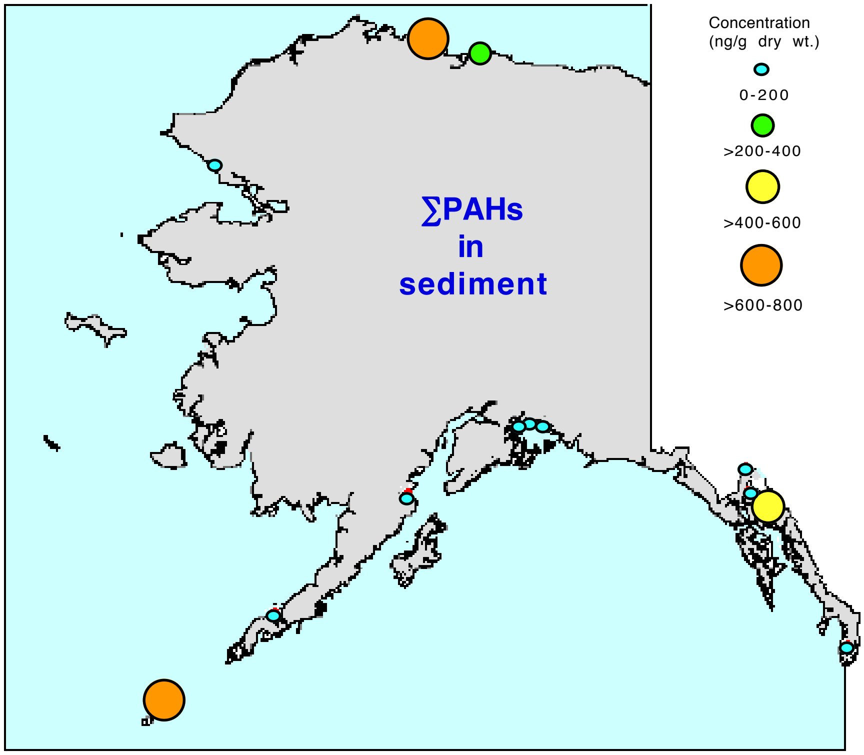


Figure II.14. ∑PAHs in sediment. Average of data from 1986 to 1995. All concentrations were below the NS&T 85th percentile (ng/g dry wt.).

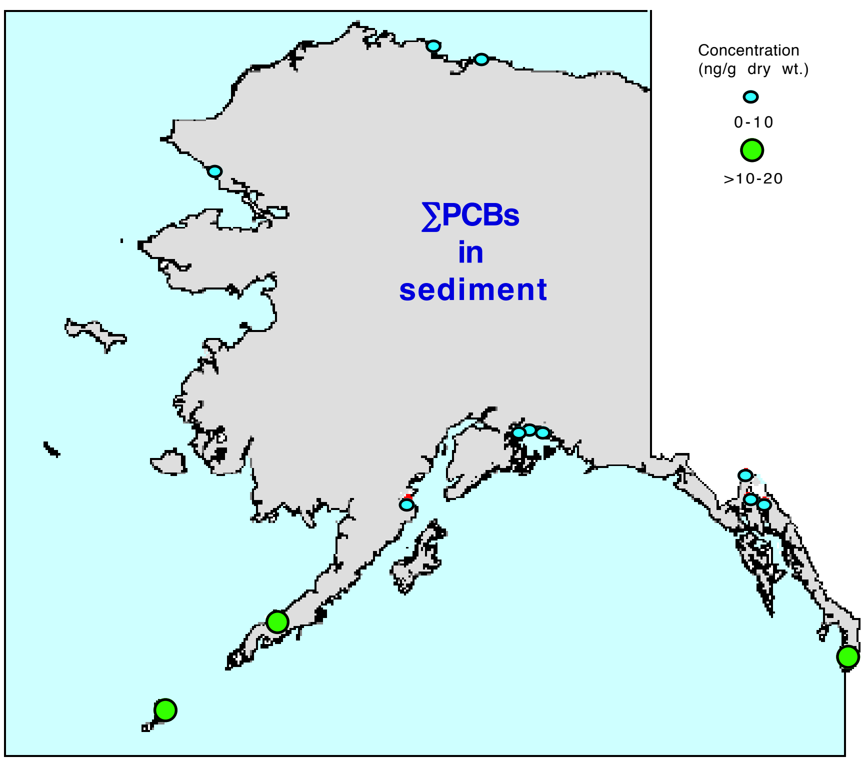


Figure II.15. ∑PCBs in sediment. Average of data from 1986 to 1995. All concentrations were below the NS&T 85th percentile (ng/g dry wt.).

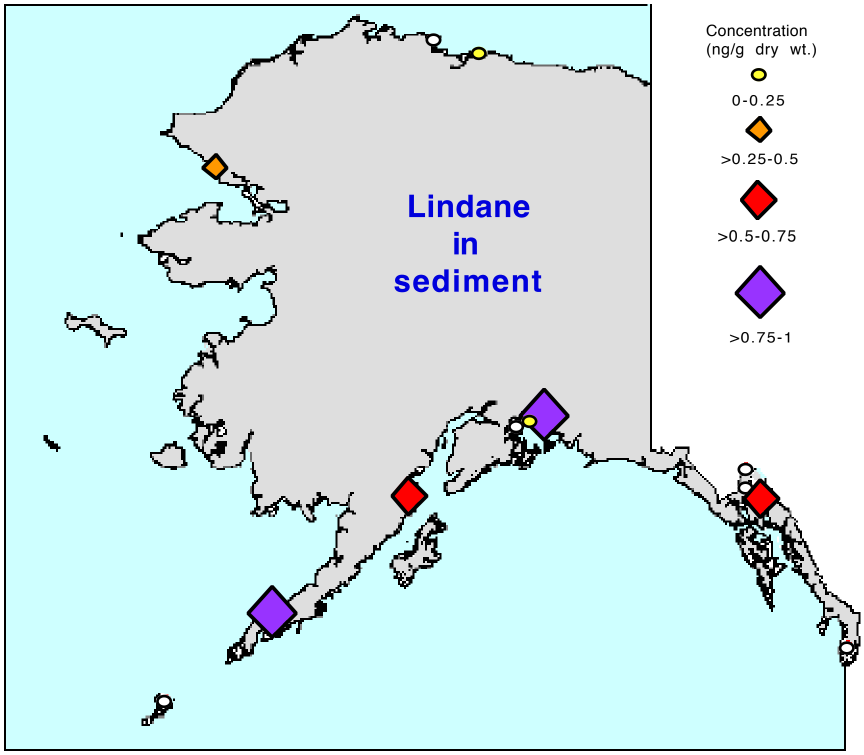


Figure II.16. Lindane in sediment. Average of data from 1986 to 1995. All concentrations were below the NS&T 85th percentile (ng/g dry wt.).

Sunset in Icy Straits area, 1991, CDR J. Bortniak, NOAA Corps (NOAA Photo Collection, NOAA Central Library)

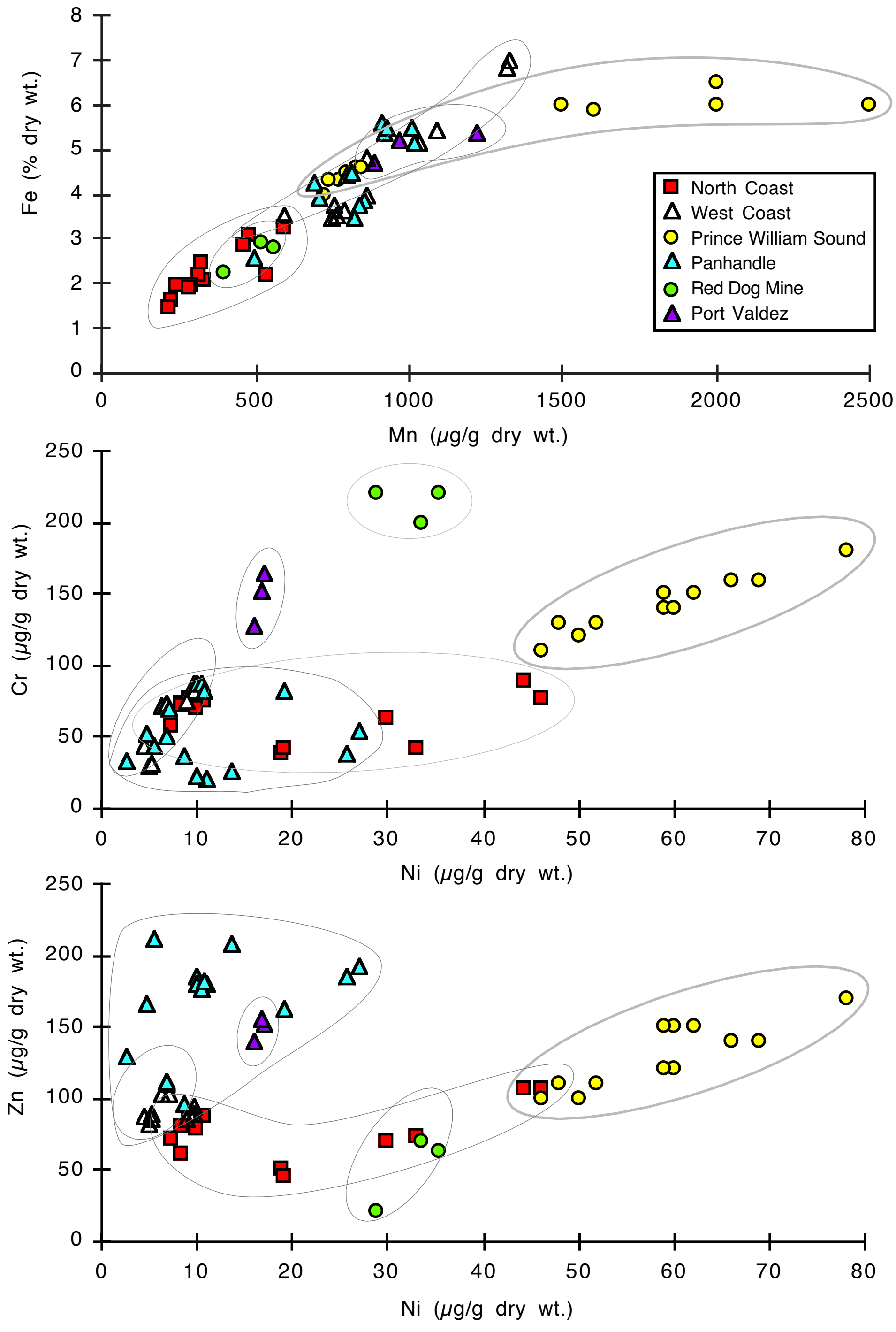


Figure II.17. Covariance of some major and trace elements in sediment. All data from 1986 to 1995 (µg/g dry wt. unless noted).

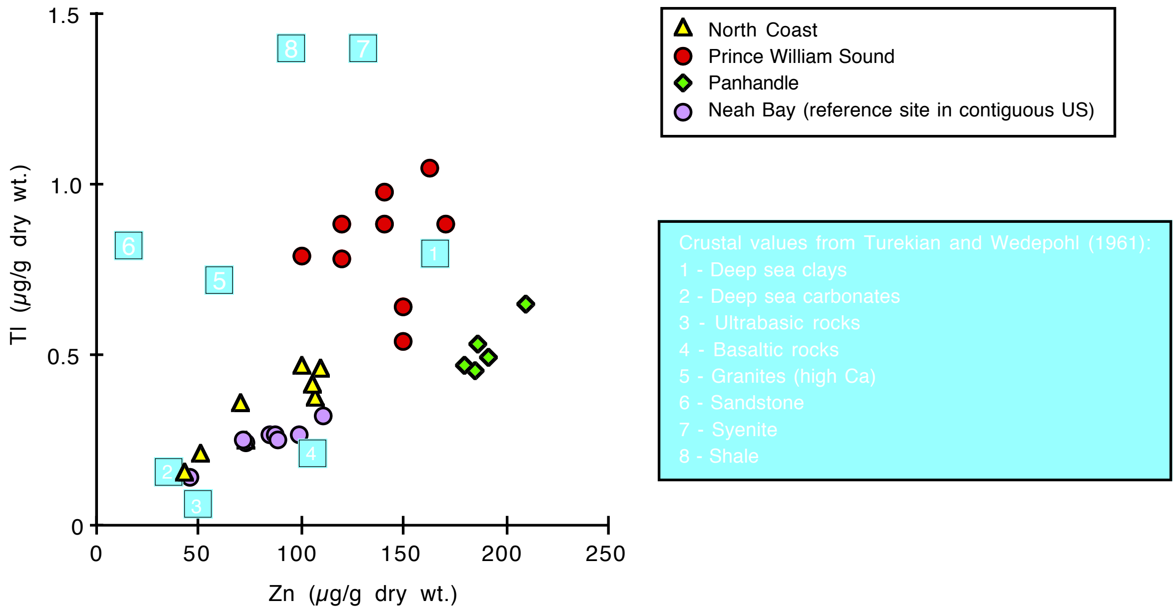


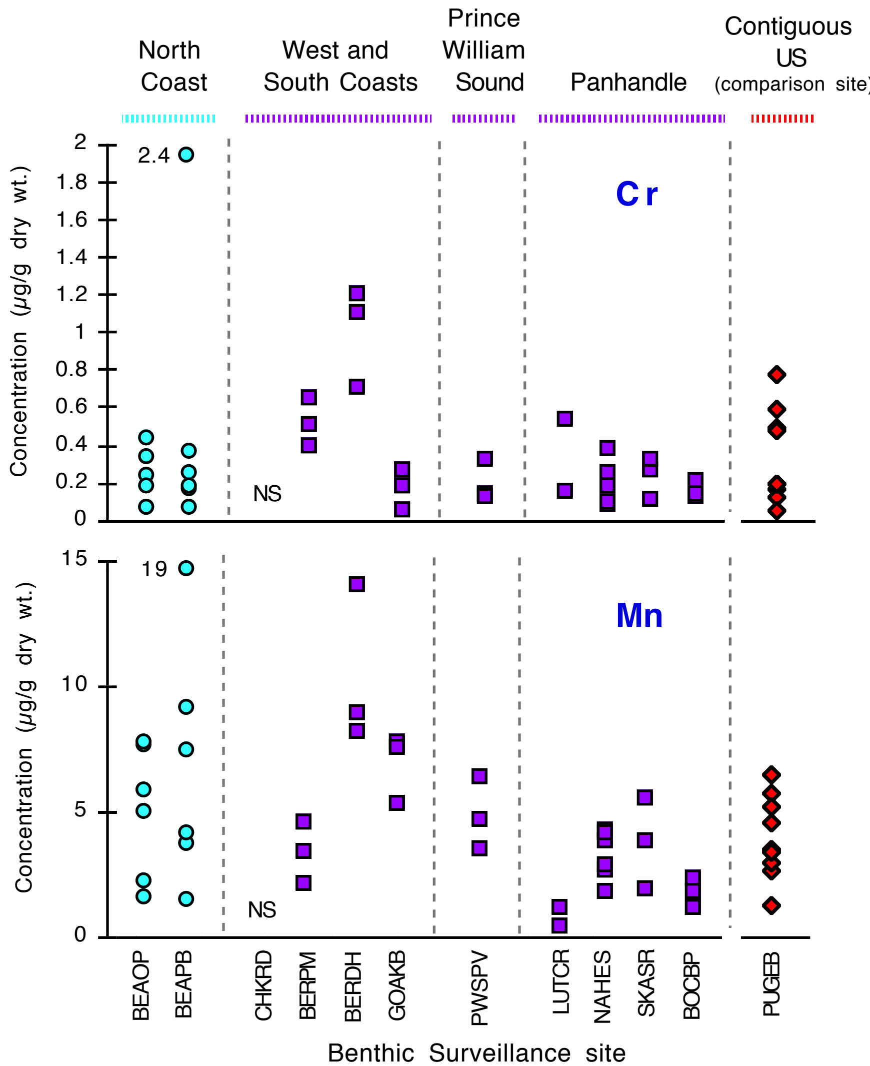
Figure II.18. Thallium and zinc in sediment. All data from 1986 to 1995. Crustal values from Turekian and Wedepohl (1961) denoted by squares (µg/g dry wt.).

Spring melt at Oliktok Point, Alaska North Slope, 1951, RADM H. D. Nygren, NOAA Corps (ret.) (NOAA Photo Collection, NOAA Central Library)p

Appendix III

NS&T fish data for Alaska

Cr and Mn in fish liver



Sites:

North Coast
- BEAOP Oliktok Point
- BEAPB Prudhoe Bay

West and South Coasts
- CHKRD Red Dog Mine
- BERPM Port Moller
- BERDH Dutch Harbor
- GOAKB Kamishak Bay

Prince William Sound
- PWSPV Port Valdez

Panhandle
- LUTCR Chilkoot River Mouth
- NAHES East Side
- SKASR Skagway River
- BOCBP Bacrian Point

Contiguous US (comparison site)
- PUGEB Elliot Bay

Species:
- ● *Myoxocephalus quadricornis*
- ■ *Hippoglossoides elassodon*
- ◆ *Parophrys vetulus*

NS - Not sampled.

Figure III.1. Chromium and manganese in fish liver (µg/g dry wt.).

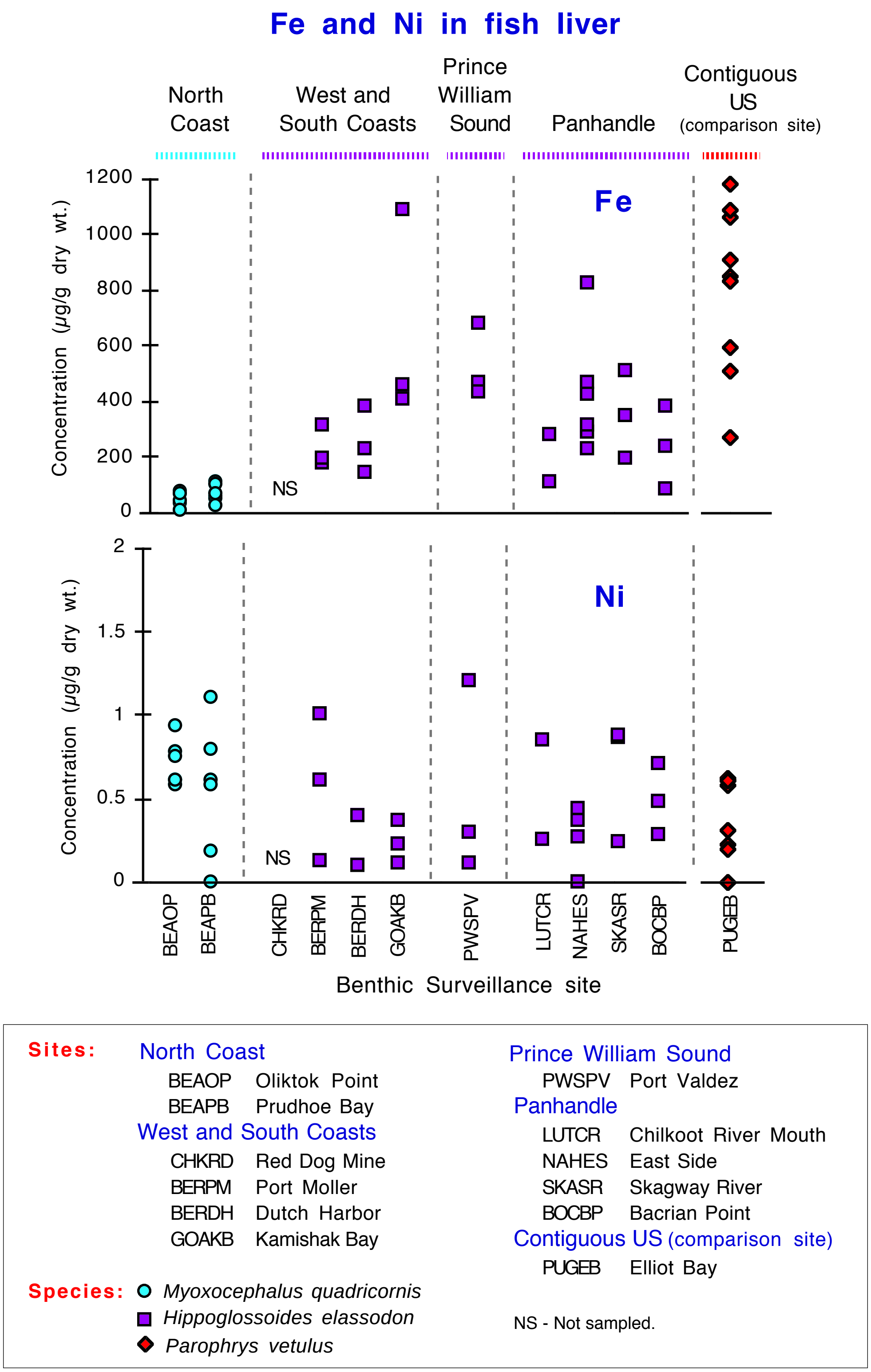


Figure III.2. Iron and nickel in fish liver (µg/g dry wt.).

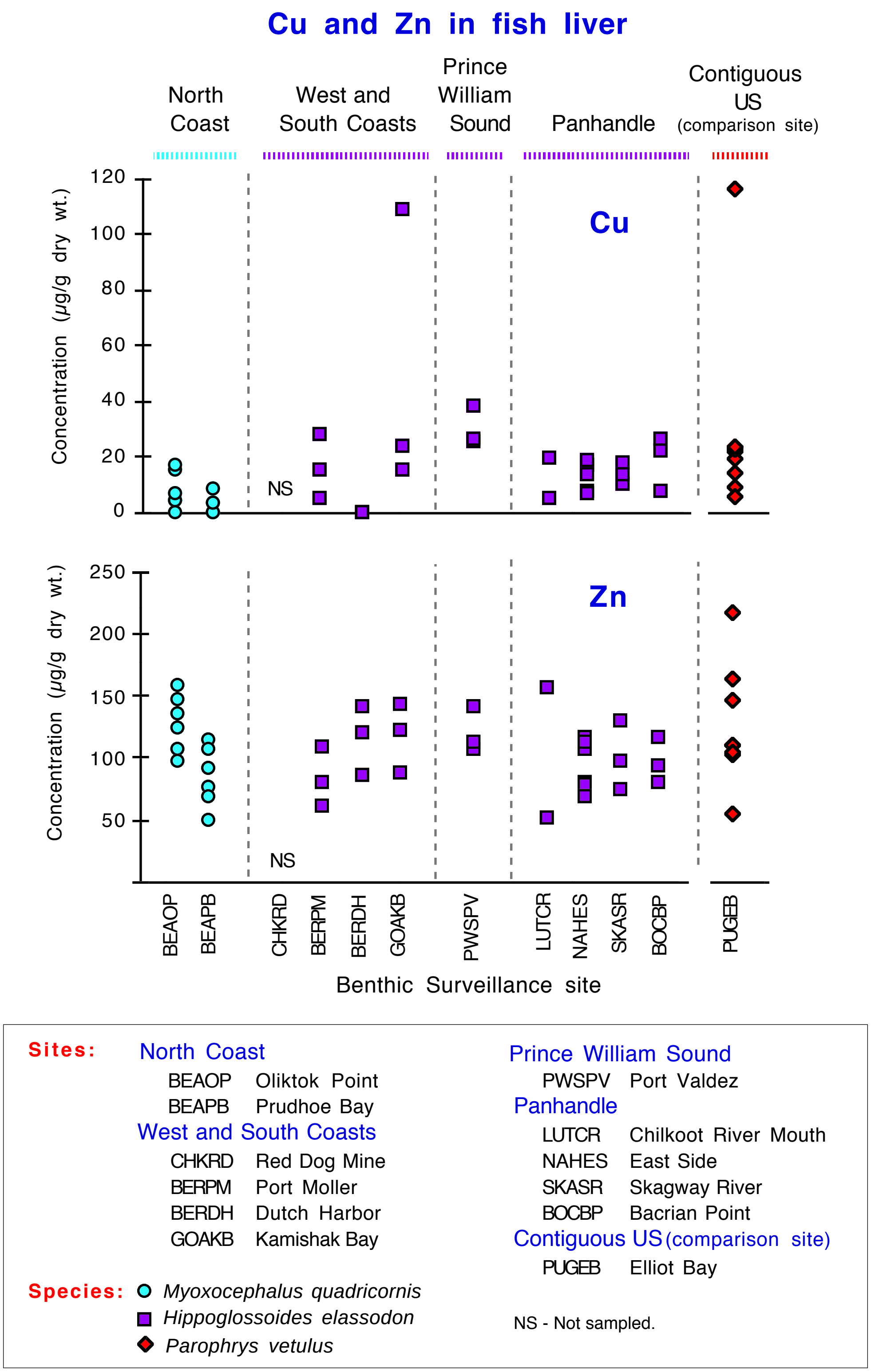
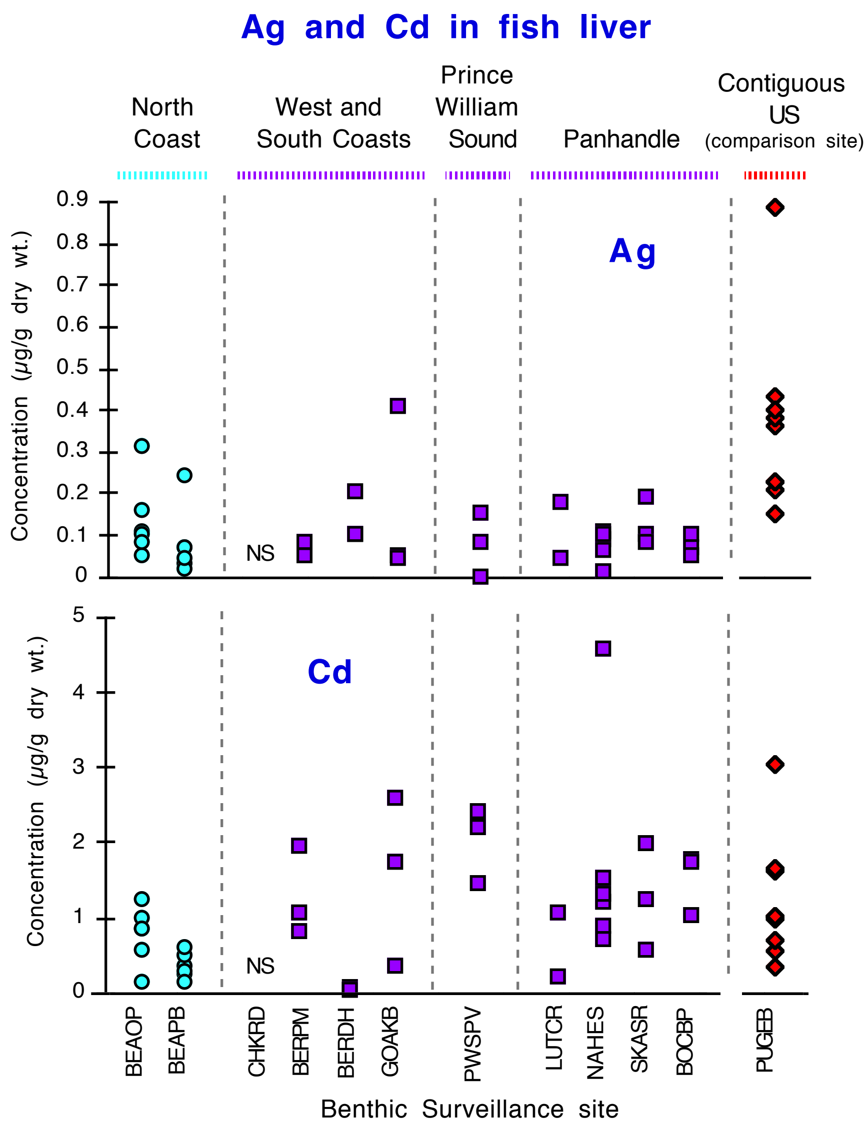


Figure III.3. Copper and zinc in fish liver (µg/g dry wt.).



Sites:

North Coast
- BEAOP Oliktok Point
- BEAPB Prudhoe Bay

West and South Coasts
- CHKRD Red Dog Mine
- BERPM Port Moller
- BERDH Dutch Harbor
- GOAKB Kamishak Bay

Prince William Sound
- PWSPV Port Valdez

Panhandle
- LUTCR Chilkoot River Mouth
- NAHES East Side
- SKASR Skagway River
- BOCBP Bacrian Point

Contiguous US (comparison site)
- PUGEB Elliot Bay

Species:
- ○ *Myoxocephalus quadricornis*
- □ *Hippoglossoides elassodon*
- ◇ *Parophrys vetulus*

NS - Not sampled.

Figure III.4. Silver and cadmium in fish liver (µg/g dry wt.).

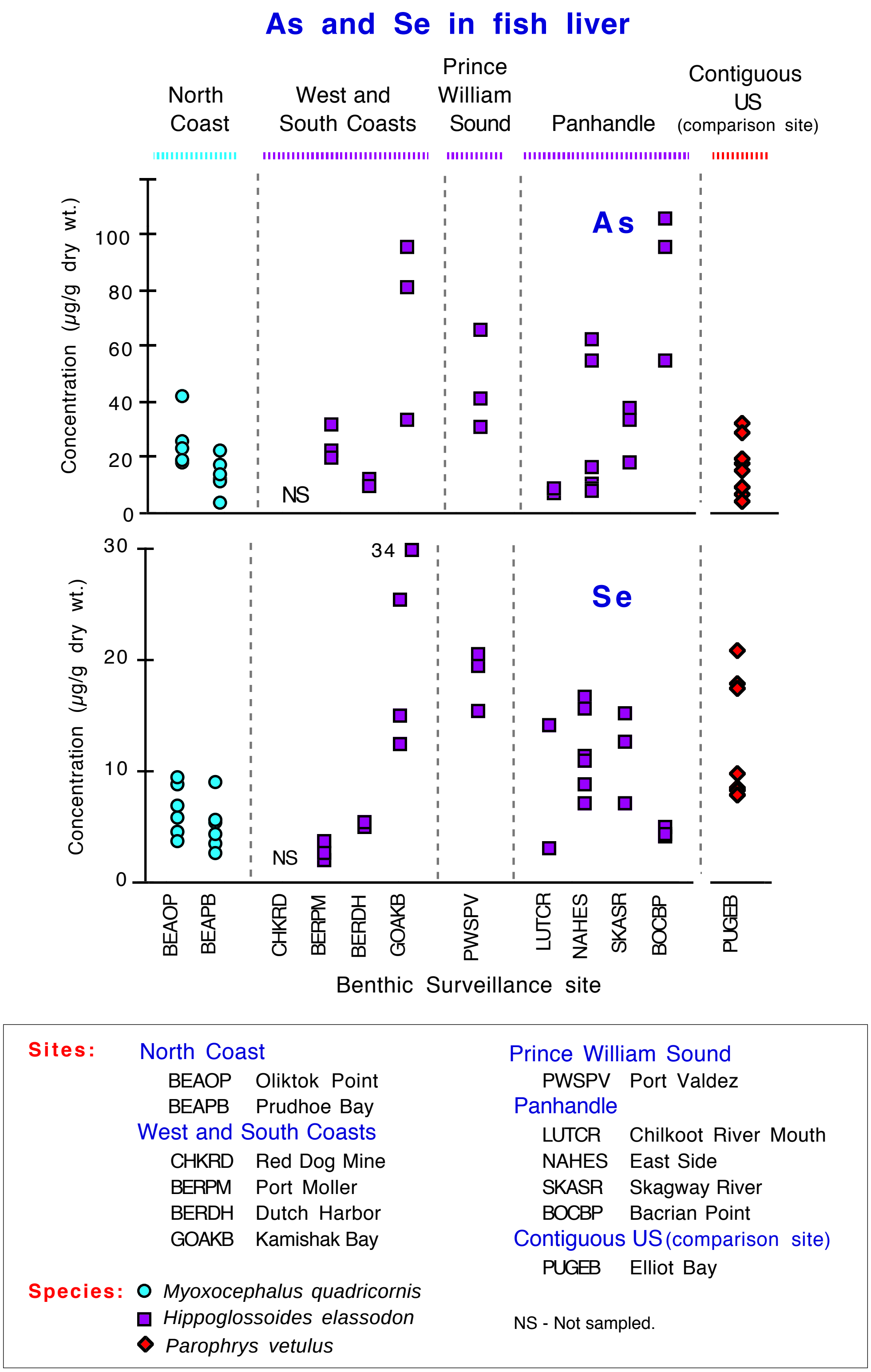
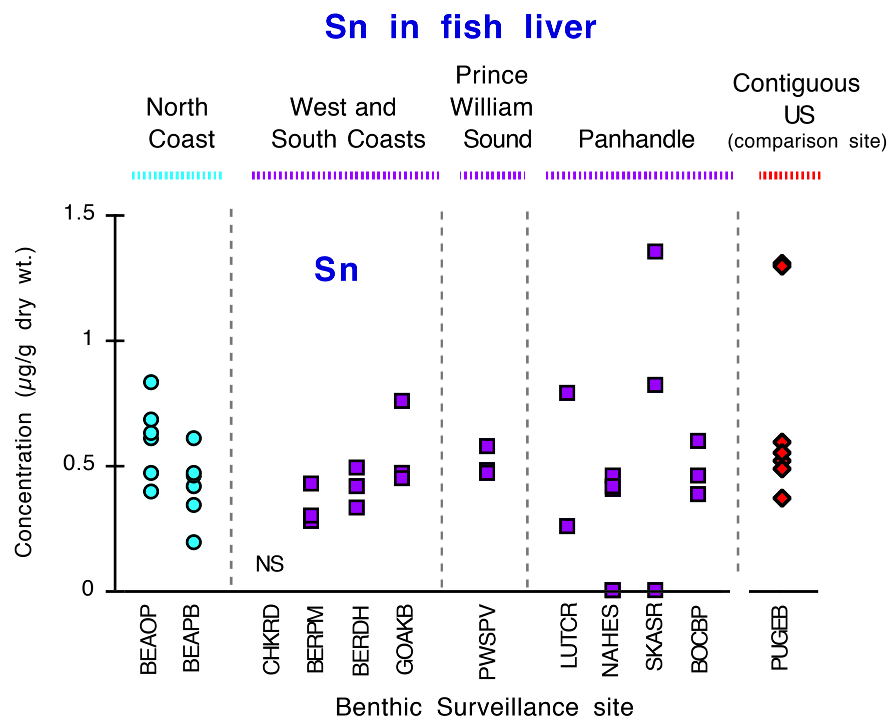


Figure III.5. Arsenic and selenium in fish liver (µg/g dry wt.).



Sites:

North Coast
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- BEAPB Prudhoe Bay

West and South Coasts
- CHKRD Red Dog Mine
- BERPM Port Moller
- BERDH Dutch Harbor
- GOAKB Kamishak Bay

Prince William Sound
- PWSPV Port Valdez

Panhandle
- LUTCR Chilkoot River Mouth
- NAHES East Side
- SKASR Skagway River
- BOCBP Bacrian Point

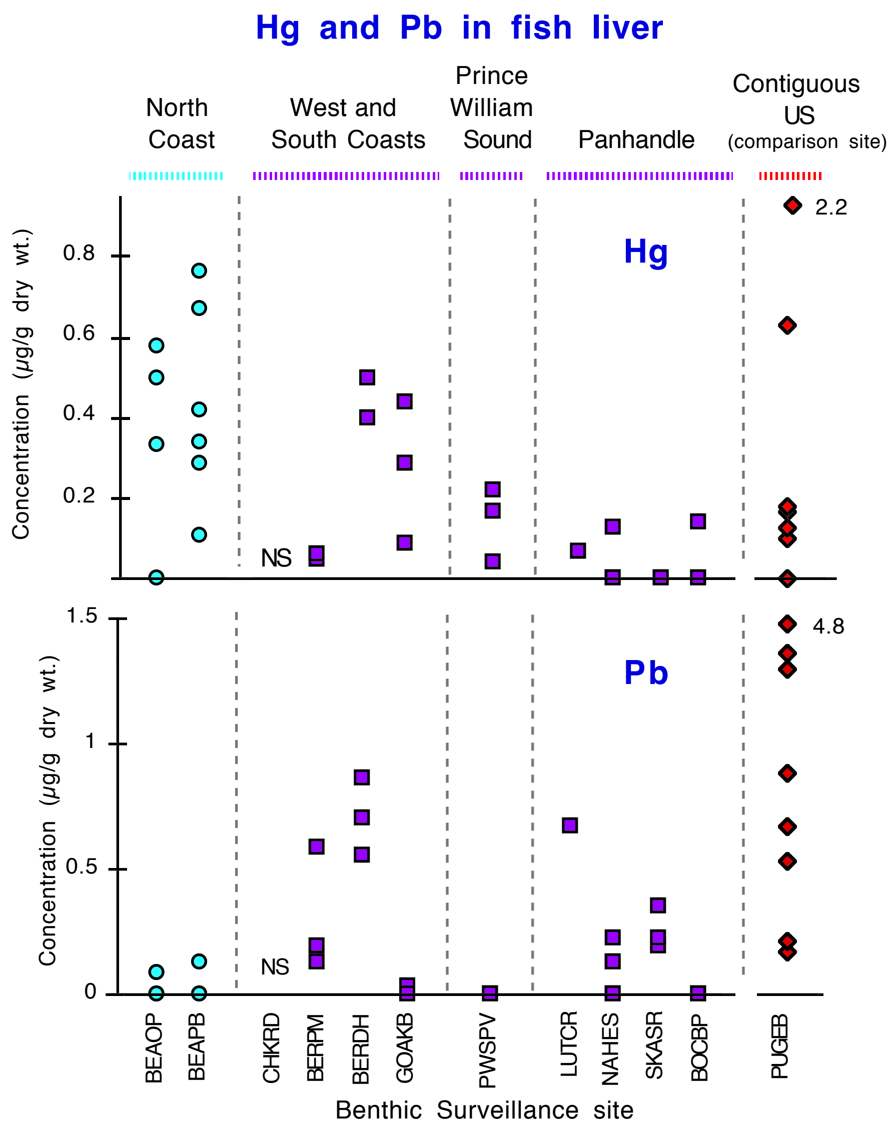
Contiguous US (comparison site)
- PUGEB Elliot Bay

Species:
- ○ *Myoxocephalus quadricornis*
- ■ *Hippoglossoides elassodon*
- ◆ *Parophrys vetulus*

NS - Not sampled.

Figure III.6. Tin in fish liver (µg/g dry wt.).

NOAA vessel JOHN N. COBB, 1991, CDR J. Bortniak, NOAA Corps (NOAA Photo Collection, NOAA Central Library)



Sites:

North Coast

BEAOP	Oliktok Point
BEAPB	Prudhoe Bay

West and South Coasts

CHKRD	Red Dog Mine
BERPM	Port Moller
BERDH	Dutch Harbor
GOAKB	Kamishak Bay

Prince William Sound

PWSPV	Port Valdez

Panhandle

LUTCR	Chilkoot River Mouth
NAHES	East Side
SKASR	Skagway River
BOCBP	Bacrian Point

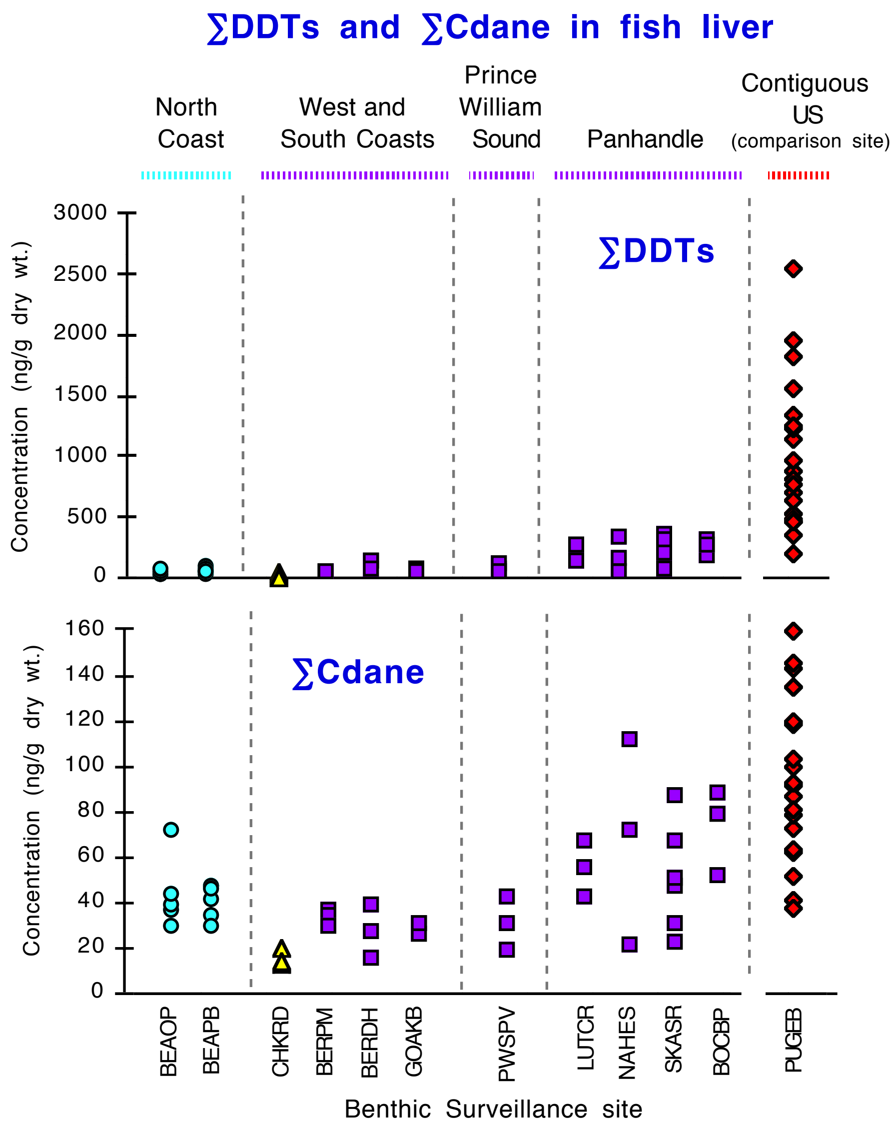
Contiguous US (comparison site)

PUGEB	Elliot Bay

Species:
- ○ *Myoxocephalus quadricornis*
- ■ *Hippoglossoides elassodon*
- ◆ *Parophrys vetulus*

NS - Not sampled.

Figure III.7. Mercury and lead in fish liver (µg/g dry wt.).



Sites:

North Coast

BEAOP	Oliktok Point
BEAPB	Prudhoe Bay

West and South Coasts

CHKRD	Red Dog Mine
BERPM	Port Moller
BERDH	Dutch Harbor
GOAKB	Kamishak Bay

Prince William Sound

PWSPV	Port Valdez

Panhandle

LUTCR	Chilkoot River Mouth
NAHES	East Side
SKASR	Skagway River
BOCBP	Bacrian Point

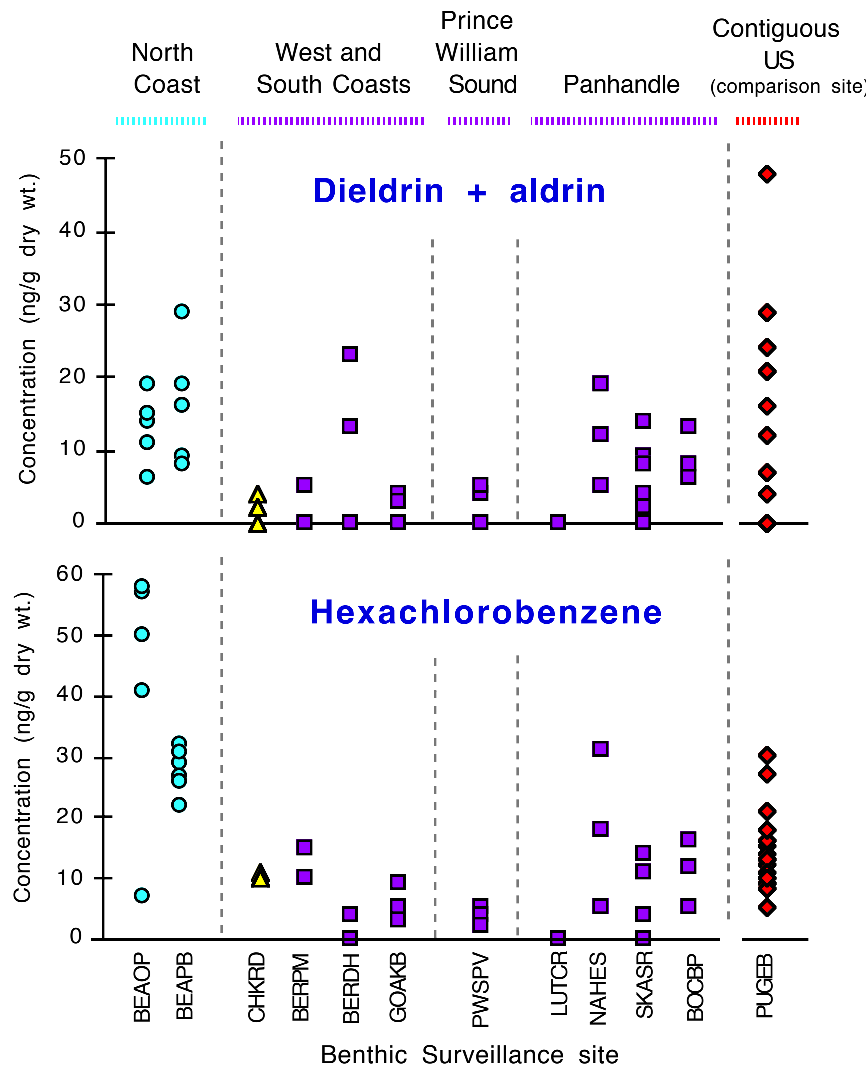
Contiguous US (comparison site)

PUGEB	Elliot Bay

Species:
- ○ *Myoxocephalus quadricornis*
- △ *Platichthys stellatus*
- □ *Hippoglossoides elassodon*
- ◇ *Parophrys vetulus* and *Hippoglossoides elassodon*

Figure III.8. ∑DDTs and metabolites and total chlordane pesticides in fish liver (ng/g dry wt.).

Dieldrin + aldrin, and hexachlorobenzene in fish liver



Sites:

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LUTCR	Chilkoot River Mouth
NAHES	East Side
SKASR	Skagway River
BOCBP	Bacrian Point

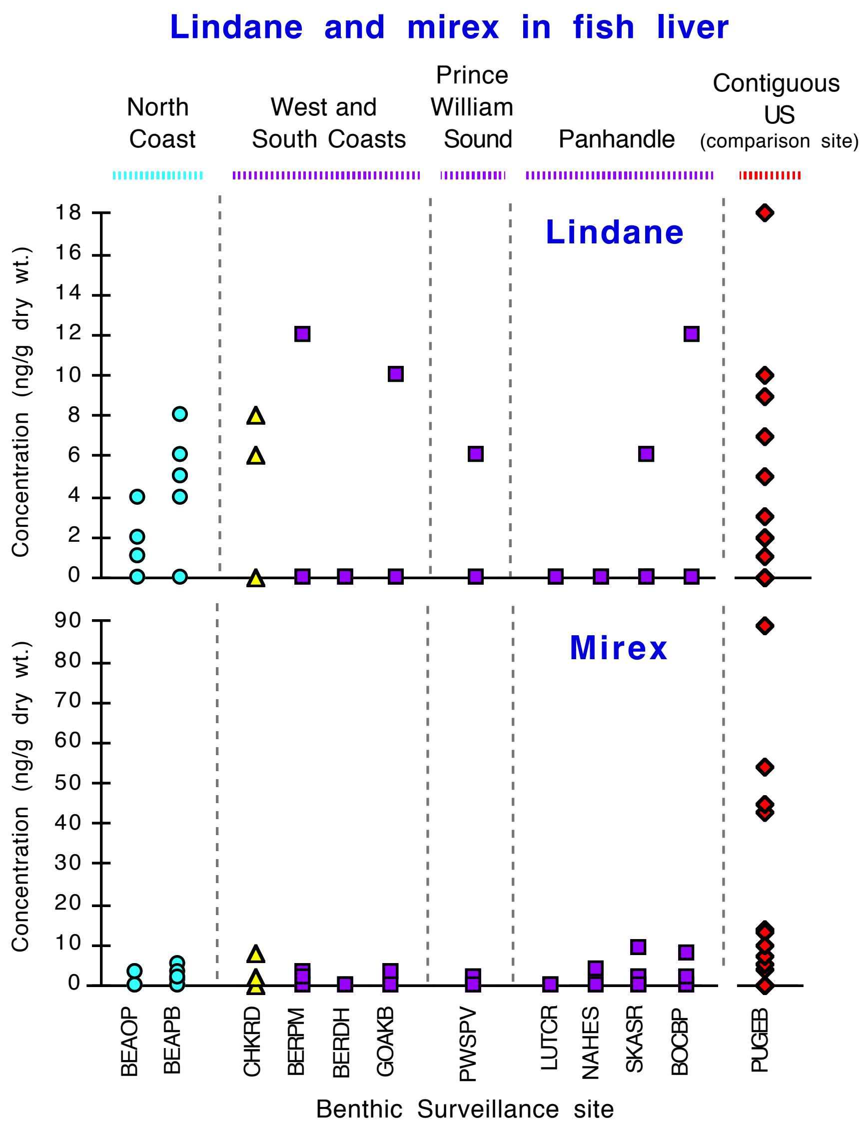
Contiguous US (comparison site)

PUGEB	Elliot Bay

Species:

- *Myoxocephalus quadricornis*
- *Platichthys stellatus*
- *Hippoglossoides elassodon*
- *Parophrys vetulus* and *Hippoglossoides elassodon*

Figure III.9. Total dieldrin and aldrin, and hexachlorobenzene in fish liver (ng/g dry wt.).



Sites:

North Coast

BEAOP	Oliktok Point
BEAPB	Prudhoe Bay

West and South Coasts

CHKRD	Red Dog Mine
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Prince William Sound

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Panhandle

LUTCR	Chilkoot River Mouth
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SKASR	Skagway River
BOCBP	Bacrian Point

Contiguous US (comparison site)

PUGEB	Elliot Bay

Species:
- ○ *Myoxocephalus quadricornis*
- △ *Platichthys stellatus*
- □ *Hippoglossoides elassodon*
- ◇ *Parophrys vetulus* and *Hippoglossoides elassodon*

Figure III.10. Lindane and mirex in fish liver (ng/g dry wt.).

Nickel and copper trends at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site

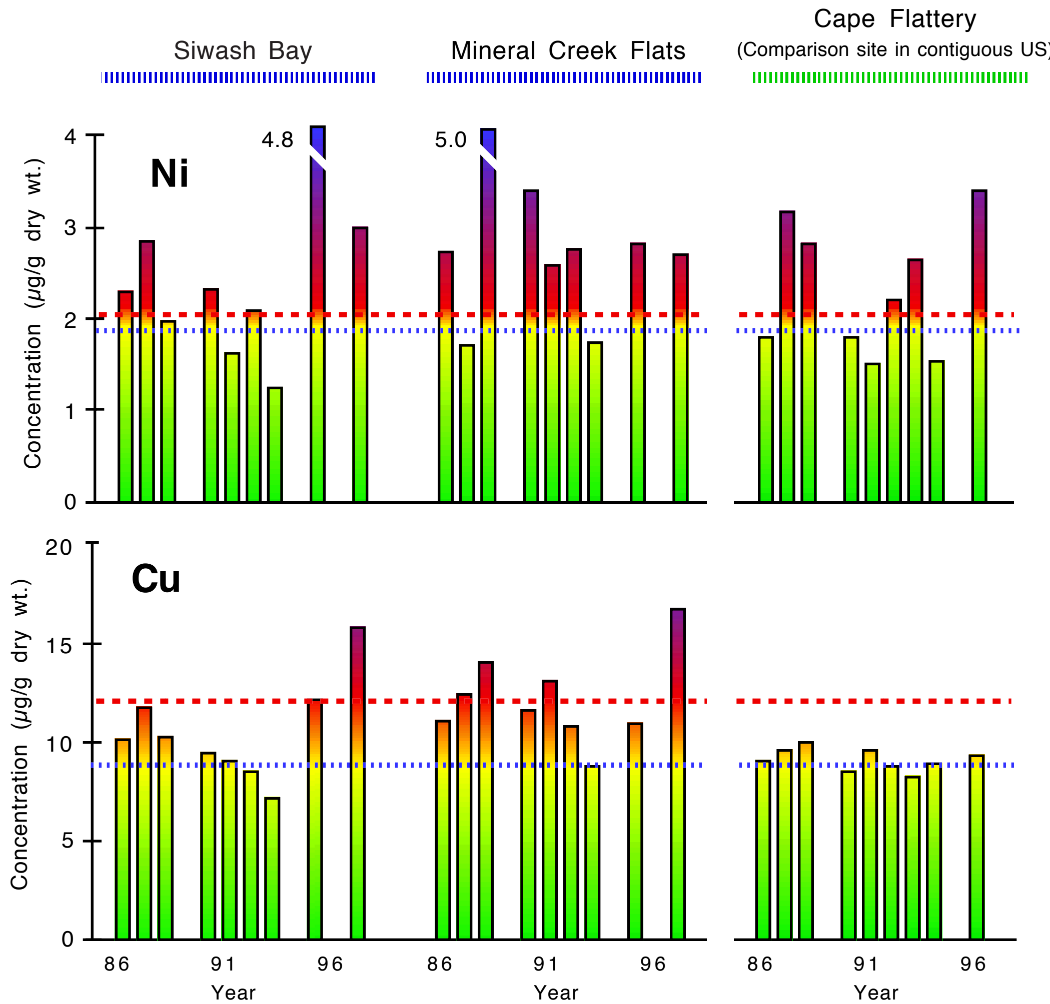


Figure IV.1. Nickel and copper trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile (μg/g dry wt.).

Zinc, arsenic, and selenium trends at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site

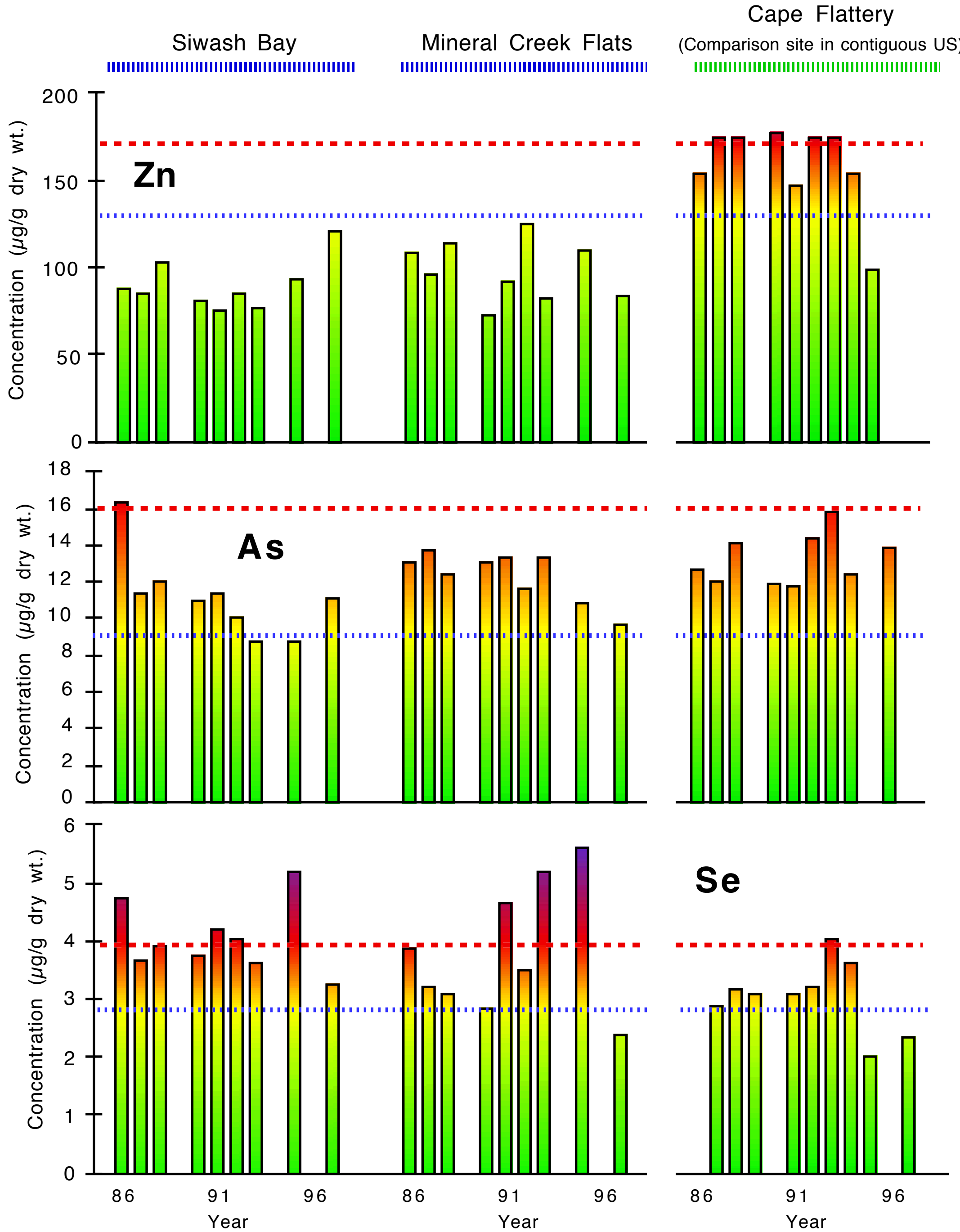
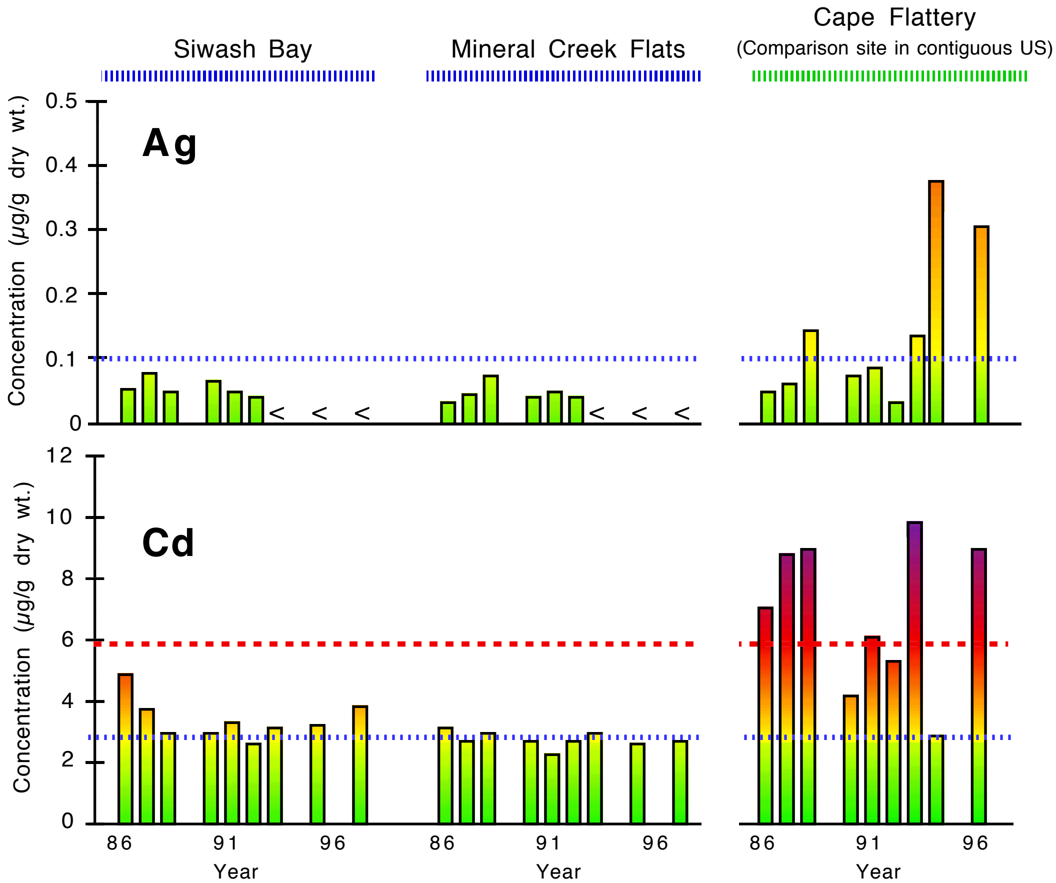


Figure IV.2. Zinc, arsenic and selenium trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile (µg/g dry wt.).

Silver and cadmium trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site



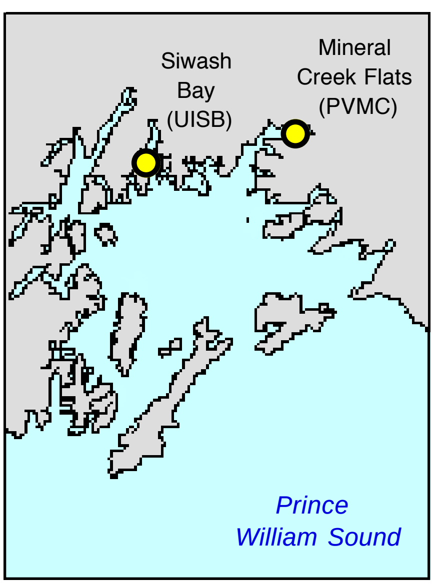


Figure IV.3. Silver and cadmium trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median. A "<" indicates a value below the limit of detection (µg/g dry wt.).

Mercury, lead, and ∑PAHs trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site

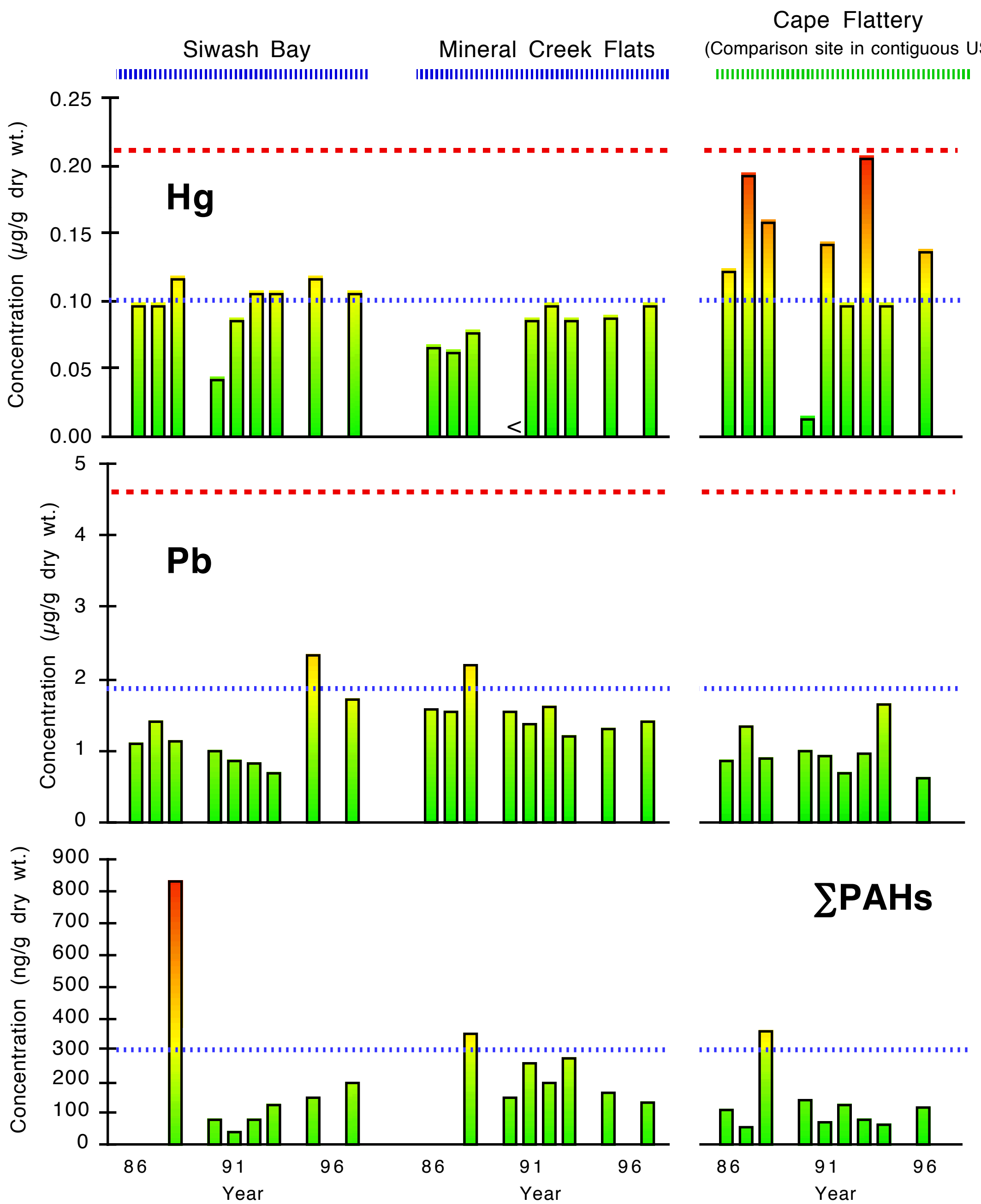
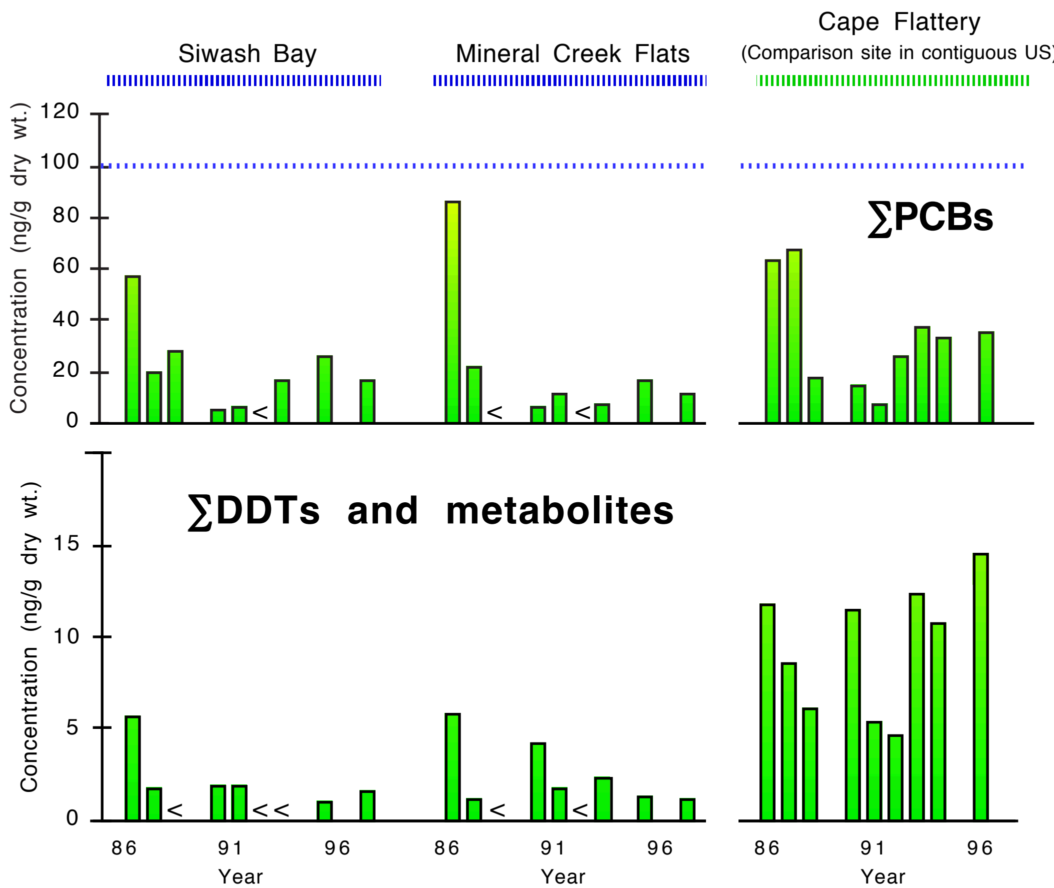


Figure IV.4. Mercury, lead, and ∑PAHs (ng/g dry wt.) trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. A "<" indicates a value below the limit of detection (µg/g dry wt. unless noted).

∑PCBs and ∑DDT s and metabolites trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site



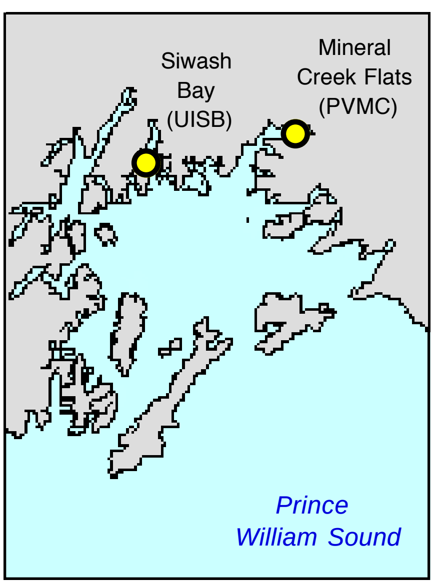


Figure IV.5. ∑PCBs and ∑DDTs and metabolites trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median. A "<" indicates a value below the limit of detection ng/g dry wt.).

Total chlordane pesticides and total tributyltins trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery, the US mainland reference site

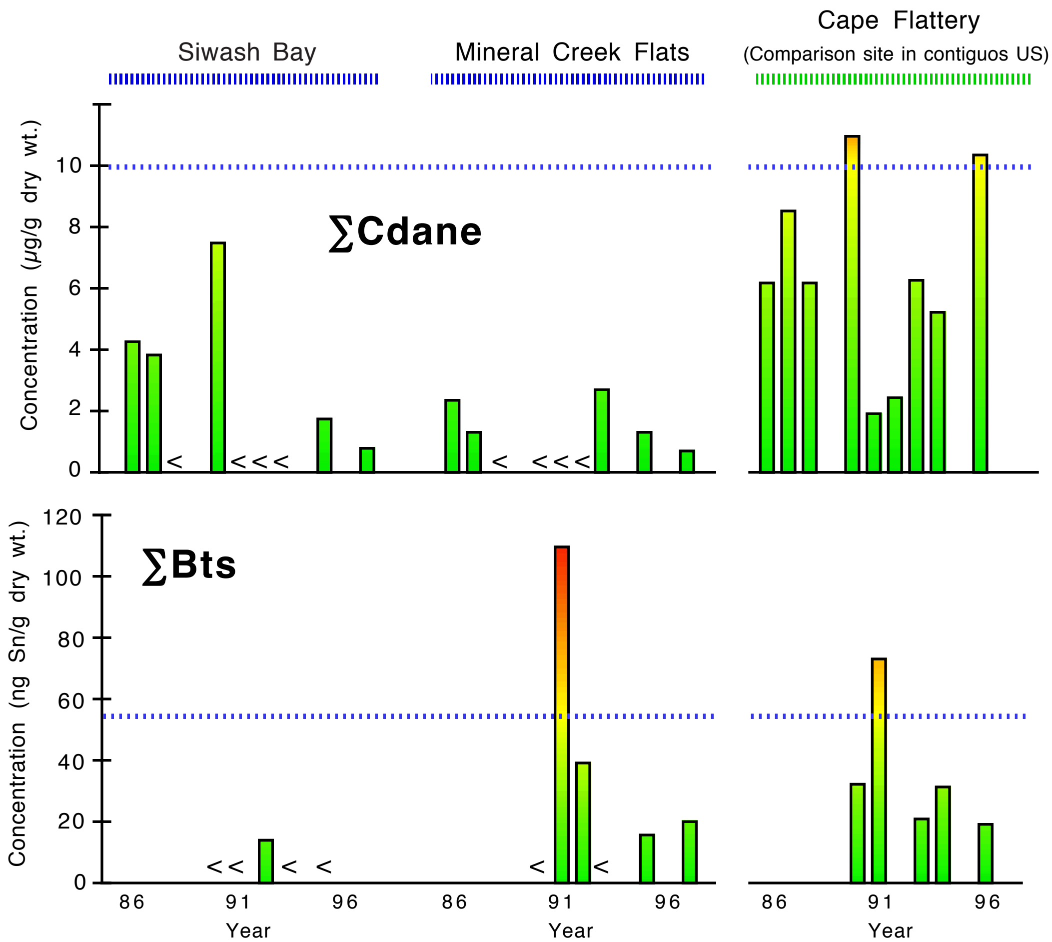


Figure IV.6. Total chlordane pesticides and total butyltins trends in mussels collected at Siwash Bay, Mineral Creek Flats, and Cape Flattery. Dotted blue line is NS&T median. A "<" indicates a value below the limit of detection (ng/g dry wt.).

Oliktok Point, Alaska North Slope, 1951, RADM H. D. Nygren, NOAA Corps (ret.)
(NOAA Photo Collection, NOAA Central Library)

U.S. Secretary of Commerce
William M. Daley

Under Secretary of Commerce for Oceans and Atmosphere, and Administrator
National Oceanic and Atmospheric Administration
D. James Baker, Ph.D.

Assistant Secretary of Commerce for Oceans and Atmosphere,
and Deputy Administrator
Terry D. Garcia

Assistant Administrator for Ocean Services and Coastal Zone Management
National Ocean Service
Nancy Foster, Ph.D.